SIMPLIFIED LIQUEFACTION HAZARDS ASSESSMENT USING STANDARD PENETRATION TEST (SPT) DATA

PROJECT INFORMATION	
Project Name	
Project No.	
Project Location	
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SELECTED METHODS OF ANALYSIS	
Analysis Description	
Triggering of Liquefaction	Boulanger-Idriss (2014)
Severity of Liquefaction	LPI: Liquefaction Potential Index based on Iwasaki et al. (1978)
Seismic Compression Settlement (Dry/Unsaturated Soil)	Pradel (1998)
Liquefaction-Induced Settlement (Saturated Soil)	Tokimatsu and Seed (1987)
Liquefaction-Induced Lateral Spreading	Zhang et al. (2004)
Residual Shear Strength of Liquefied Soil	Idriss and Boulanger (2008)

SEISMIC DESIGN PARAMETERS		
Earthquake Moment Magnitude, M_w	7.00	
Peak Ground Acceleration, A_{max}	0.47	g
Factor of Safety Against Liquefaction, FS	1.30	

BORING DATA AND SITE CONDITION		
Boring No.	B-3	
Ground Surface Elevation	400.0	feet
Proposed Grade Elevation	400.0	feet
GWL Depth Measured During Test	20.0	feet
GWL Depth Used in Design	15.0	feet
Borehole Diameter	8.0	inches
Hammer Weight	140.0	pounds
Hammer Drop	30.0	inches
Hammer Energy Efficiency Ratio, ER (%)	80.0	%
Hammer Distance to Ground Surface	5.0	feet
Topographic Site Condition:	TSC3	(Level Ground with Nearby Free Face)
- Ground Slope, S (%)	<<= Leave this blank	
- Free Face Distance to Slope Height Ratio, (L/H)	5.0 <<= Enter (L/H)	Enter H ==> 10.0 feet

INPUT SOIL PROFILE DATA

Depth to Top of Soil Layer (feet)	Depth to Bottom of Soil Layer (feet)	Material Type USCS Group Symbol (ASTM D2487)	Liquefaction Screening *Susceptible Soil? (Y, N)*	Total Soil Unit Weight γ_t (pcf)	Type of Soil Sampler	Field Blow Count N_{field} (blows/ft)	Fines Content FC (%)
0.0	5.0	SM	Y	120.0	SPT1	35.0	30.0
5.0	7.5	SM	Y	120.0	SPT1	25.0	30.0
7.5	10.0	SM	Y	120.0	SPT1	18.0	30.0
10.0	15.0	SM	Y	115.0	MCal	10.0	15.0
15.0	20.0	SM	Y	115.0	MCal	12.0	15.0
20.0	25.0	SM	Y	115.0	SPT1	14.0	15.0
25.0	30.0	SM	Y	115.0	SPT1	20.0	15.0
30.0	35.0	SP	Y	115.0	SPT1	28.0	5.0
35.0	40.0	SP	Y	115.0	SPT1	45.0	5.0
40.0	45.0	SP	Y	115.0	SPT1	40.0	5.0
45.0	50.0	SP	Y	115.0	SPT1	48.0	5.0

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Hammer Weight	140.00 pounds	
Hammer Drop	30.00 inches	
Hammer Energy Efficiency Ratio, ER	80.00 %	
Hammer Distance to Ground Surface	5.00 feet	
Topographic Site Condition:	TSC3	(Level Ground with Nearby Free Face)
- Ground Slope, S	N/A	
- Free Face (L/H) Ratio	5.00	H = 10 feet

SUMMARY OF RESULTS

Severity of Liquefaction:

Total Thickness of Liquefiable Soils:	10.00 feet	
Liquefaction Potential Index (LPI):	14.62	*** (High risk, with moderate liquefaction effects)

Seismic Ground Settlements:

Seismic Compression Settlement:	0.23 inches	(Dry/Unsaturated Soils)	Pradel (1998)
Liquefaction-Induced Settlement:	2.22 inches	(Saturated Soils)	Tokimatsu and Seed (1987)
Total Seismic Settlement:	2.45 inches		

Seismic Lateral Displacements:

Cyclic Lateral Displacement:	1.45 inches	(During Ground Shaking)	Tokimatsu and Asaka (1998)
Lateral Displacement Index (LDI):	11.39 inches		
Lateral Spreading Displacement:	13.27 inches	(After Ground Shaking)	Zhang et al. (2004)

NOTES AND REFERENCES

\+ This method of analysis is based on observed seismic performance of level ground sites using correlation with normalized and fines-corrected SPT blow count, $(N_1)_{60cs} = f\{(N_1)_{60}, FC\}$ where $(N_1)_{60} = N_{field}\, C_N\, C_E\, C_B\, C_R\, C_S$

++ Liquefaction susceptibility screening is performed to identify soil layers assessed to be non-liquefiable based on laboratory test results using the criteria proposed by Cetin and Seed (2003), Bray and Sancio (2006), or Idriss and Boulanger (2008).

* FS_{liq} = Factor of Safety against liquefaction = (CRR/CSR), where $CRR = CRR_{7.5}\, MSF\, K_\sigma\, K_\alpha$, MSF = Magnitude Scaling Factor, $K_\sigma = f[(N_1)_{60}, \sigma'_{vo}]$, $K_\alpha = 1.0$, (level ground), CSR = Cyclic Stress Ratio = $0.65\, A_{max}\, (\sigma_{vo}/\sigma'_{vo})\, r_d$, and $CRR_{7.5}$ = Cyclic Resistance Ratio is a function of $(N_1)_{60cs}$ and corrected for an earthquake magnitude M_w of 7.5.

** Residual strength values of liquefied soils are based on correlation with post-earthquake, normalized and fines-corrected SPT blow count derived by Idriss and Boulanger (2008).

*** Based on Iwasaki et al. (1978) and Toprak and Holzer (2003)

\+ Reference: Boulanger, R.W. and Idriss, I.M. (2014), "CPT and SPT Based Liquefaction Triggering Procedures," University of California Davis, Center for Geotechnical Modeling Report No. UCD/CGM-14/01, 1-134.

INPUT SOIL PROFILE DATA								LIQUEFACTION TRIGGERING ANALYSIS BASED ON R.W. BOULANGER AND I.M. IDRISS (2014) METHOD +																					
Depth to Top of Soil Layer (feet)	Depth to Bottom of Soil Layer (feet)	Material Type USCS Group Symbol (ASTM D2487)	Liquefaction Susceptibility Screening ++ Susceptible Soil? (Y/N)	Total Soil Unit Weight γ_t (pcf)	Type of Soil Sampler	Field SPT Blow Count N_{field} (blows/ft)	Fines Content FC (%)	Total Vert. Stress (Design) σ_{vo} (psf)	Effective Vert. Stress (Design) σ'_{vo} (psf)	SPT Corr. for Vert. Stress C_N	SPT Corr. for Hammer Energy C_E	SPT Corr. for Borehole Size C_B	SPT Corr. for Rod Length C_R	SPT Corr. for Sampling Method C_S	Corrected SPT Blow Count N_{60}	Normalized SPT Blow Count $(N_1)_{60}$	Fines Corrected SPT Blow Count $(N_1)_{60cs}$	Shear Stress Reduction Coefficient r_d	Correction for High Overburden Stress K_σ	Cyclic Stress Ratio CSR	Cyclic Resistance Ratio CRR	Factor of Safety * FS_{liq}	Liquefaction Analysis Results	Residual Shear Strength ** S_r (psf)	Seismic Porewater Pressure Ratio r_u (%)	Cumulative Seismic Settlement (inches)	Cumulative Cyclic Lateral Displacement (inches)	Cumulative Lateral Spreading Displacement (inches)
0.0	5.0	SM	Y	120.0	SPT1	35.0	30.0	300.00	300.00	1.451	1.333	1.150	0.750	1.000	40.3	58.4	63.8	1.000	1.100	0.305						2.45	1.45	13.27
5.0	7.5	SM	Y	120.0	SPT1	25.0	30.0	750.00	750.00	1.333	1.333	1.150	0.800	1.000	30.7	40.9	46.2	0.988	1.100	0.302						2.45	1.45	13.27
7.5	10.0	SM	Y	120.0	SPT1	18.0	30.0	1,050.00	1,050.00	1.266	1.333	1.150	0.850	1.000	23.5	29.7	35.1	0.979	1.100	0.299						2.45	1.45	13.27
10.0	15.0	SM	Y	115.0	MCal	10.0	15.0	1,487.50	1,487.50	1.174	1.333	1.150	0.850	0.650	8.5	9.9	13.2	0.964	1.027	0.294						2.44	1.44	13.27
15.0	20.0	SM	Y	115.0	MCal	12.0	15.0	2,062.50	1,906.50	0.984	1.333	1.150	0.950	0.650	11.4	11.2	14.4	0.941	0.997	0.311	0.159	0.51	LIQUEFY	206.57	100.00	2.22	1.38	13.27
20.0	25.0	SM	Y	115.0	SPT1	14.0	15.0	2,637.50	2,169.50	0.907	1.333	1.150	0.950	1.000	20.4	18.5	21.8	0.917	0.973	0.341	0.245	0.72	LIQUEFY	376.77	100.00	0.89	0.43	0.00
25.0	30.0	SM	Y	115.0	SPT1	20.0	15.0	3,212.50	2,432.50	0.883	1.333	1.150	0.950	1.000	29.1	25.7	29.0	0.891	0.947	0.360	0.472	1.31			43.38	0.00	0.16	0.00
30.0	35.0	SP	Y	115.0	SPT1	28.0	5.0	3,787.50	2,695.50	0.881	1.333	1.150	1.000	1.000	42.9	37.8	37.8	0.864	0.878	0.371						0.00	0.00	0.00
35.0	40.0	SP	Y	115.0	SPT1	45.0	5.0	4,362.50	2,958.50	0.919	1.333	1.150	1.000	1.000	69.0	63.4	63.4	0.837	0.852	0.377						0.00	0.00	0.00
40.0	45.0	SP	Y	115.0	SPT1	40.0	5.0	4,937.50	3,221.50	0.883	1.333	1.150	1.000	1.000	61.3	54.2	54.2	0.809	0.829	0.379						0.00	0.00	0.00
45.0	50.0	SP	Y	115.0	SPT1	48.0	5.0	5,512.50	3,484.50	0.904	1.333	1.150	1.000	1.000	73.6	66.5	66.5	0.781	0.808	0.377						0.00	0.00	0.00

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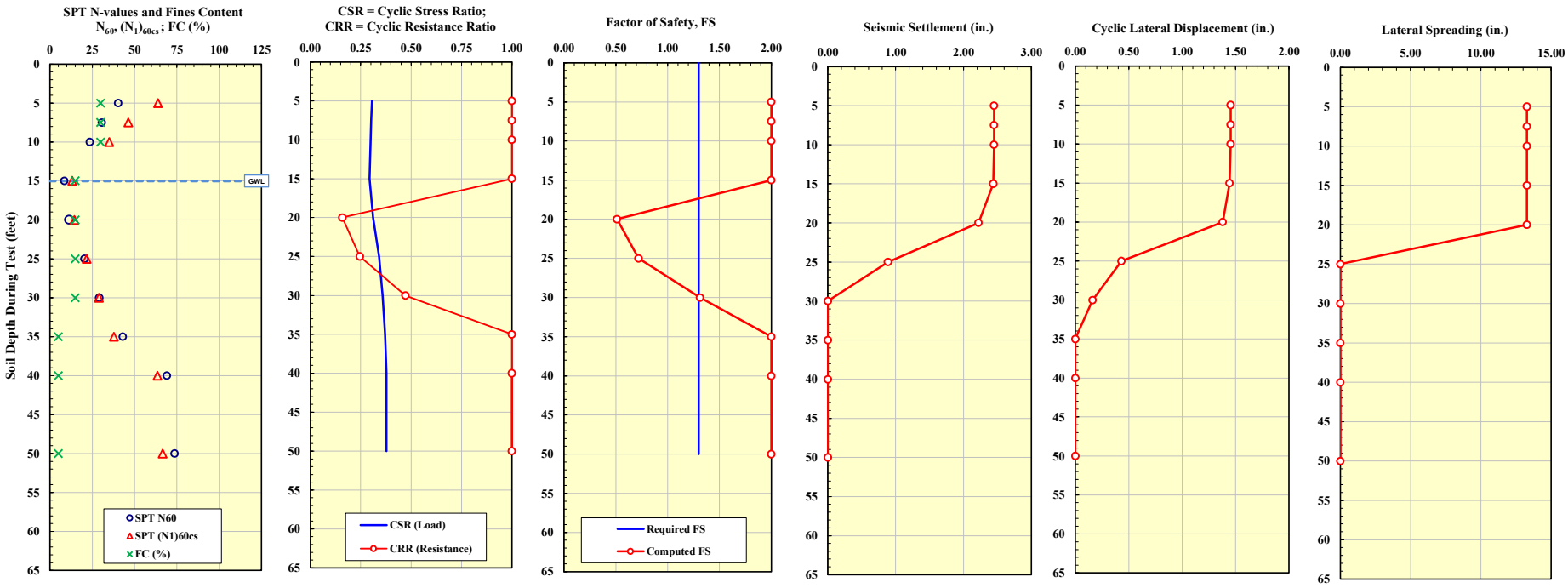

Analysis Methods Used ==>>

Liquefaction Triggering:		Seismic Settlements:	Cyclic Lateral Displacements:	Lateral Spreading:
Boulanger-Idriss (2014)	Above GWL:	Pradel (1998)	Pradel (1998)	Zhang et al. (2004)
	Below GWL:	Tokimatsu and Seed (1987)	Tokimatsu and Asaka (1998)	

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1. Boulanger, R.W. and Idriss, I.M. (2014), "CPT and SPT Based Liquefaction Triggering Procedures," University of California Davis, Center for Geotechnical Modeling Report No. UCD/CGM-14/01, 1-134.
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