

June 21, 2023

Mr. Billy Hardwick  
Archer United Joint Venture

Re: **Carolina Crossroads Phase 1**  
**Bridge 35, End Bent 1**  
Review of As Installed Timber Pile Ground Modification  
Project ID P039718  
Richland and Lexington County, South Carolina

Dear Mr. Hardwick:

Infrastructure Consulting & Engineering, PLLC (ICE) has completed a review of the as installed timber piles for the ground modification at End Bent 1 on Bridge 35 on the above referenced project. A significant portion of the timber piles terminated pile driving above plan minimum tip elevation after meeting axial capacity driving requirements.

An additional eight (8) CPT soundings were performed within the limits of the timber pile improved footprint, after completion of timber pile driving. One of these CPT soundings, CPT-9A, refused on a shallow obstruction at a depth of 3.8 ft and has been ignored for the purpose of this analysis. A summary of the CPT locations is presented in the appendix. CPT-1 and CPT-3 performed during the original design investigation phase are also within the limits of the timber pile ground improvements and is plotted for reference.

The shear strength profiles from the eight new CPT soundings along with the original CPT-1 and CPT-3 shear strength profiles are plotted in appendix A. Based on an assessment of the additional data, a revised SSL was performed and shear strength profile vs depth design model was prepared. These were used to perform an updated pseudo-static global stability model for the EEI load case analysis where seismic loading was applied as an additional horizontal loading in the direction of slope failure. The seismic load  $k_h$  is adjusted for slope height and a wave scattering scaling factor. Seismic instability was checked based on the horizontal yield acceleration value  $k_y$  for circular and non-circular failure mode models.

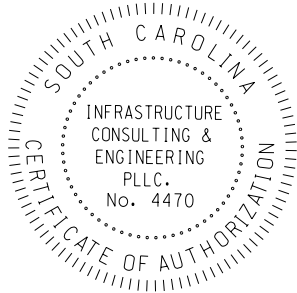
The results of the SSL screening indicated potential for SSL below the planned bridge embankment. Sporadic thin, less than 6 inches thick, isolated pockets are present within the alluvial layer above the residual soils. A thicker deposit of alluvial soils subject to SSL was encountered at the base of the alluvial layer in the majority of the new CPT soundings. This deeper SSL layer was measured at 0.2 ft to 1.9 ft thick. An SSL susceptible layer thickness of 1.5 ft was used in the updated global stability model. The presence of the upper SSL susceptible pockets within the alluvial deposit are accounted for in a conservative assessment of the shear strength of the alluvial layer above the deposit base SSL susceptible material.

Utilizing the updated global stability model, the performance of the embankment was found to exceed that provided for in the RFC FBGER in regard to the EE1 performance limit while ignoring shear reinforcement contributions from the timber piles. The reinforcement contribution from the LTP geosynthetic was included in the revised model. The EE1 performance limit was the critical design case from the FBGER. The calculated Newmark deformation for the revised models are 0.6” and 1.0” for the front slope and side slope respectively. These are reduced from the original design model Newmark deformations of 0.87” and 1.7”.

A model incorporating deformation compatibility between the global stability failure surface and timber pile shear reinforcement was not performed as the slope stability model met performance requirements without the timber pile shear reinforcement. The timber piles were analyzed for combined bending axial and bending moments at the anticipated unreinforced Newmark deformations and found to be structurally adequate. The presented deformations are conservative and would be further reduced if shear contributions from the timber piles were included.

No long-term embankment settlement is anticipated as the timber piles were driven to axial bearing requirements and load transfer platform has been designed to carry the entire weight of the embankment to stiff underlying soils.

Sincerely,  
Infrastructure Consulting & Engineering (ICE), PLLC



Michael D. Valiquette, P.E.  
Project Lead Geotechnical Engineer, Br 35 GEOR  
South Carolina PE License No. 34056

**Carolina Crossroads Phase 1 - Segment 2**  
**Richland and Lexington Counties, SC**  
**Boring Location Summary**

Boring Name	Latitude	Longitude	Northing	Easting	Alignment	Station	Offset	Elevation (feet)	Depth (feet)	0 Hr GW (feet)	24 Hr GW (feet)	0 Hr GW Elevation (feet)	24 Hr GW Elevation (feet)	Drilling Method	Test Type	Purpose/Location
CPT-7A	34.0251559	-81.10245949	797470.651	1968955.593	I26CDW3 BD	7391+05	4.1' RT	170.285	11.81	5.0	NM	165.3	NA	CPT	CPT	Embankment
CPT-12B	34.02515271	-81.10242783	797469.483	1968965.186	I26CDW3 BD	7391+03	5.2' LT	170.413	11.15	4.0	NM	166.4	NA	CPT	CPT	Embankment
CPT-11B	34.02515468	-81.10237553	797470.183	1968981.031	I26CDW3 BD	7390+96	19.5' LT	169.944	11.48	6.0	NM	163.9	NA	CPT	CPT	Embankment
CPT-8A	34.02516896	-81.10232067	797475.362	1968997.656	I26CDW3 BD	7390+85	32.9' LT	169.481	8.40	5.0	NM	164.5	NA	CPT	CPT	Embankment
CPT-14B	34.02517649	-81.10228995	797478.093	1969006.965	I26CDW3 BD	7390+79	40.4' LT	169.589	12.27	5.0	NM	164.6	NA	CPT	CPT	Embankment
CPT-10B	34.02518559	-81.10225975	797481.396	1969016.117	I26CDW3 BD	7390+72	47.6' LT	169.488	12.30	4.2	NM	165.3	NA	CPT	CPT	Embankment
CPT-9A	34.0251947	-81.10223192	797484.702	1969024.552	I26CDW3 BD	7390+66	54.1' LT	169.337	3.80	NM	NM	NA	NA	CPT	CPT	Embankment
CPT-13B	34.02520155	-81.1022107	797487.189	1969030.984	I26CDW3 BD	7390+61	59.0' LT	169.484	11.02	5.0	NM	164.5	NA	CPT	CPT	Embankment

FIAD - Filled Immediately After Drilling









	Ground El	Termination Depth	Termination El	GW Depth	GW Elevation	Deeper SSL					Upper SSL Elevation					Su Above 164	Su Below 164
						SSL Top Depth	SSL Bottom Depth	SSL Top Elevation	SSL Bottom Elevation	Deeper SSL Height	SSL Top Depth	SSL Bottom Depth	SSL Top Elevation	SSL Bottom Elevation	Upper SSL Height		
CPT-7A	170.285	11.8	158.5	5.0	165.3	11.1	11.8	159.2	158.5	0.7						1009	962
CPT-12B	170.413	11.1	159.3	4.0	166.4	10.5	11.1	159.9	159.3	0.6	6.9	7.2	163.5	163.2	0.3	1194	1979
CPT-11B	169.944	11.5	158.4	6.0	163.9	9.7	10.9	160.2	159.0	1.2	6.5	8.0	163.4	161.9	1.5	1964	2962
CPT-8A	169.481	8.4	161.1	5.0	164.5	8.2	8.4	161.3	161.1	0.2						1641	3559
CPT-14B	169.589	12.3	157.3	5.0	164.6	10.3	12.2	159.3	157.4	1.9	7.2	7.7	162.4	161.9	0.5	1441	2137
CPT-10B	169.488	12.3	157.2	4.2	165.3	11.1	12.3	158.4	157.2	1.2						1151	2170
CPT-13B	169.337	11.0	158.3	5.0	164.3	10.3	11.0	159.0	158.3	0.7	5.1	5.5	164.2	163.8	0.4	854	2187
Average	169.484	11.2	158.6	4.9	164.9	10.2	11.1	159.6	158.7	0.9	6.4	7.1	163.4	162.7	0.7	1322	2279

Ignore CPT-9A due to early termination

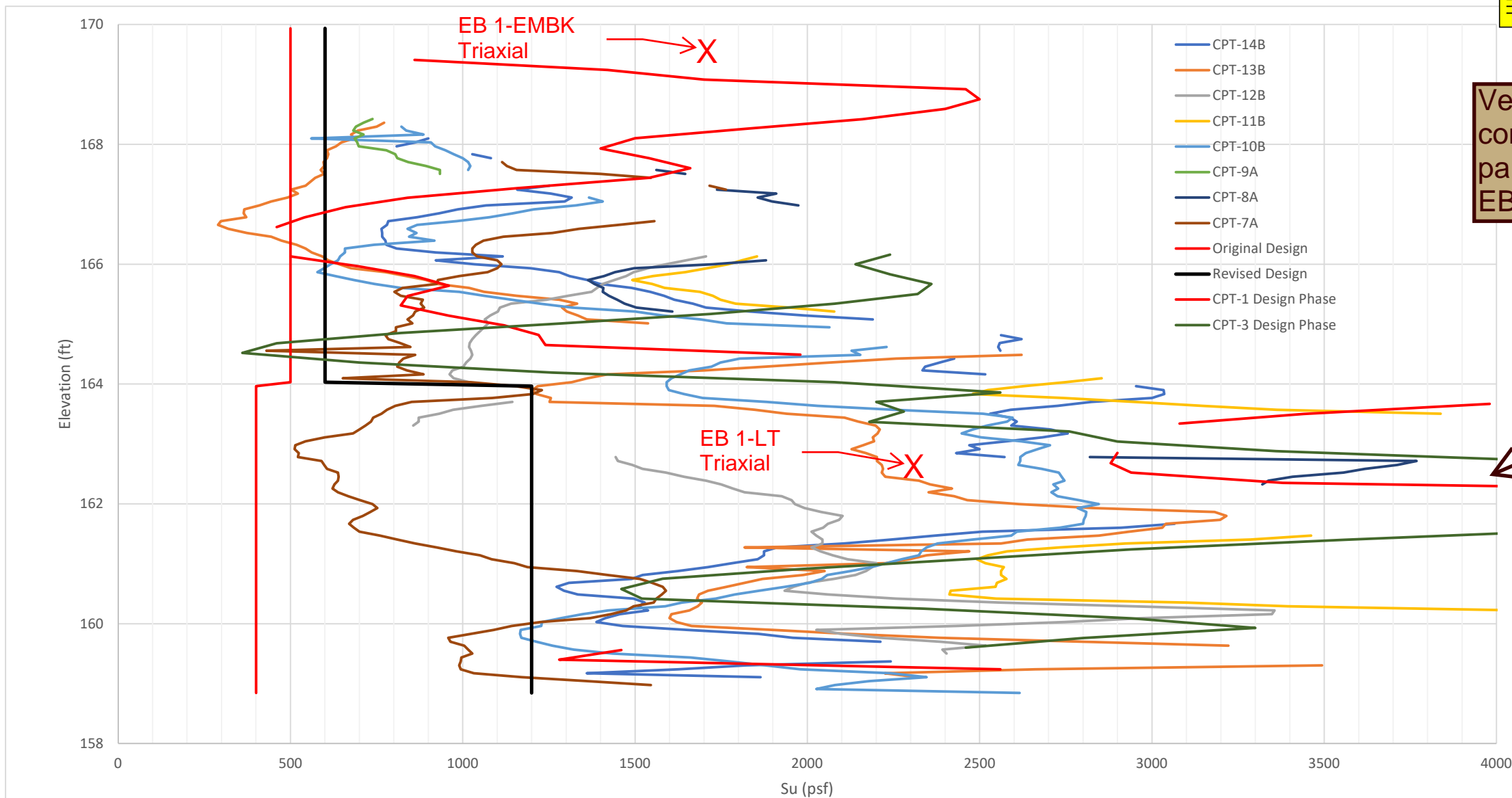
Original Design	172
Revised Design	172

156
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164		160	156	4
164		160	158.5	1.5

Ignore Upper SSL Layer as it is less than 6" thick and is not contiguous between CPT Soundings

500	400
600	1200



Verify that the 1200 psf value is consistent with the soil parameters from the EB 1-LT and EB 1-EMBK triaxial testing.

1200 psf is conservative relative to the undrained shear strengths from EB 1-LT and EB1-EMBK triaxial testing. Those results are 2300 psf and 1700 psf, respectively. They have been added to the presented cpt plots for comparison.

Confirm that Equation 7-35 of the GDM was used for the Su correlations and provide the Nk value that was used.

Confirmed, Equation 7-35 was used for all CPT's plotted using an Nk of 14

**LIQUEFACTION ANALYSIS REPORT**

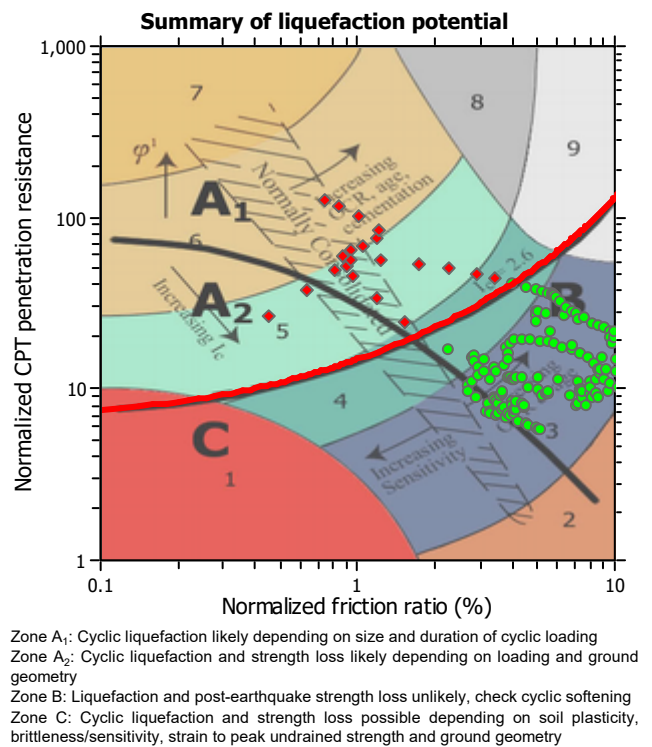
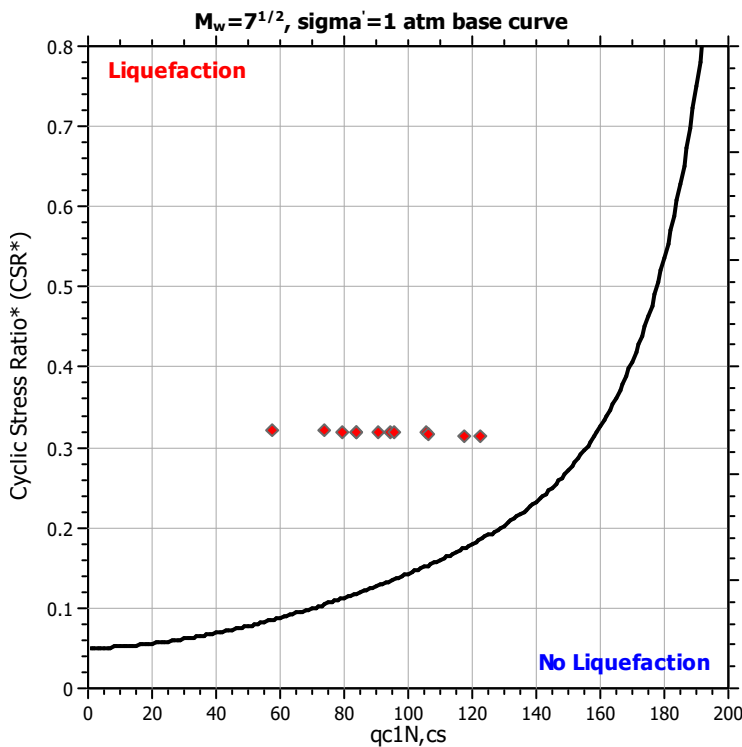
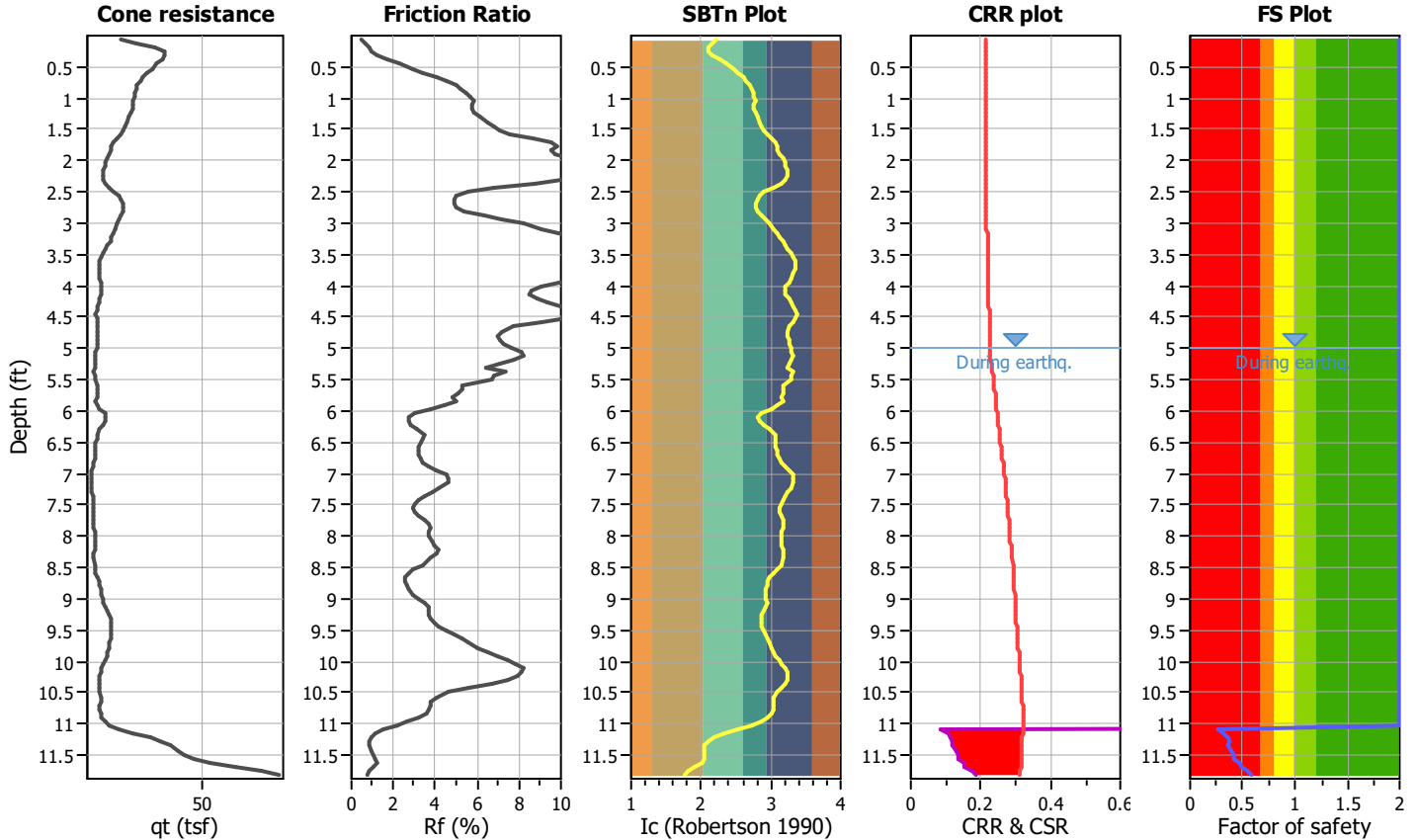
**Project title : CCR Ph 1**

**Location :**

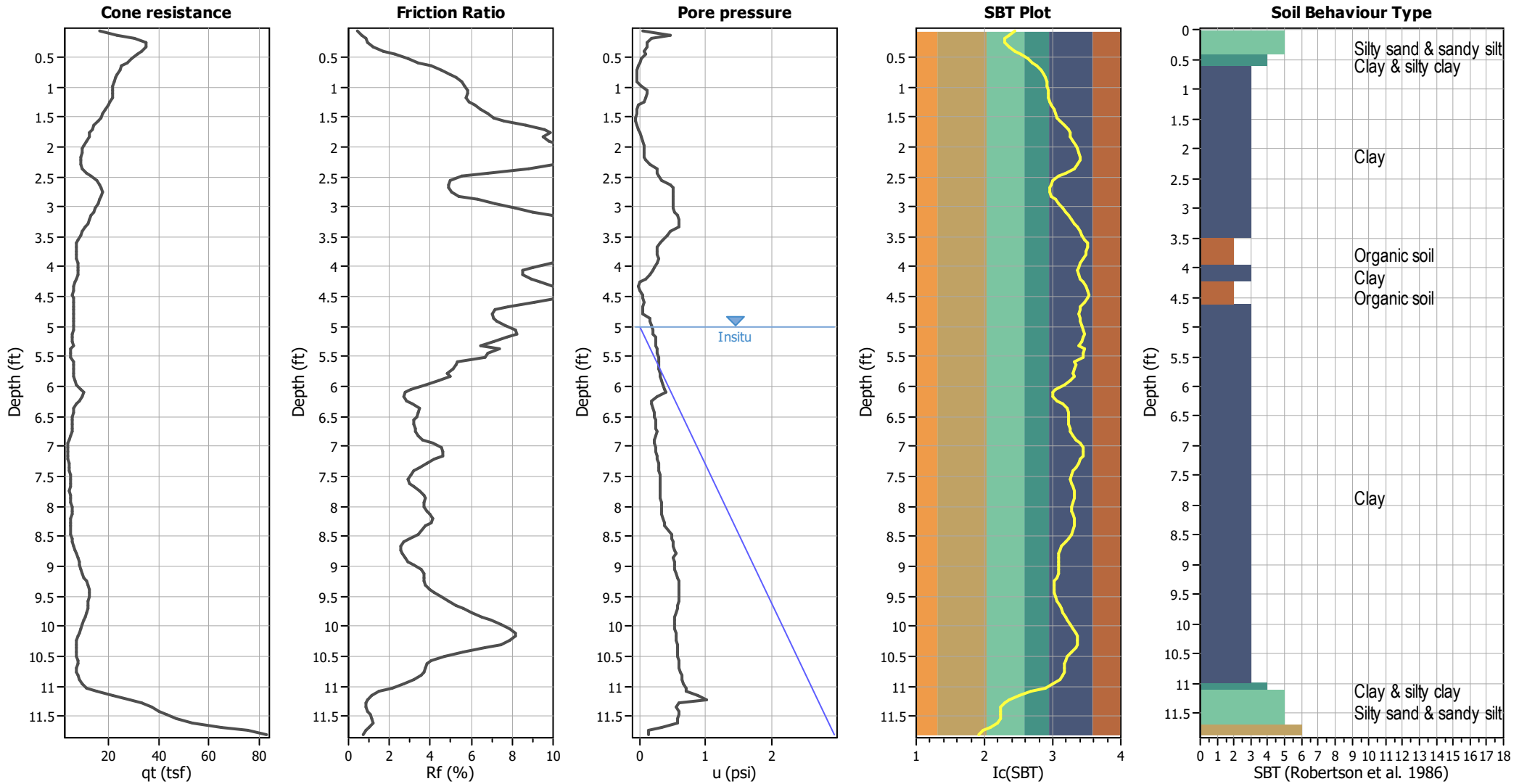
**CPT file : CPT-7A**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	5.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	5.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude $M_w$ :	7.28	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.39	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		



### CPT basic interpretation plots



#### Input parameters and analysis data

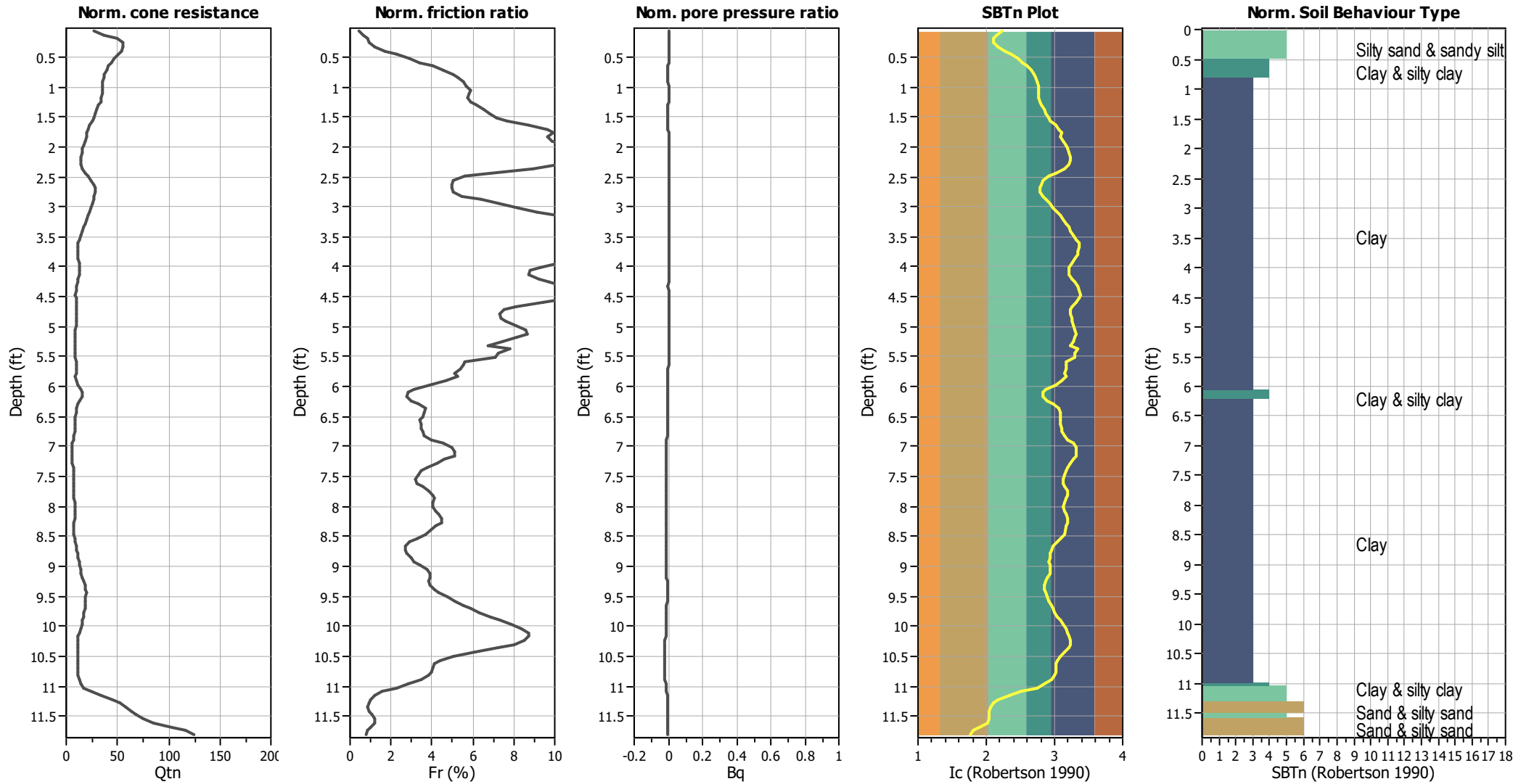
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Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

#### SBT legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained



### CPT basic interpretation plots (normalized)



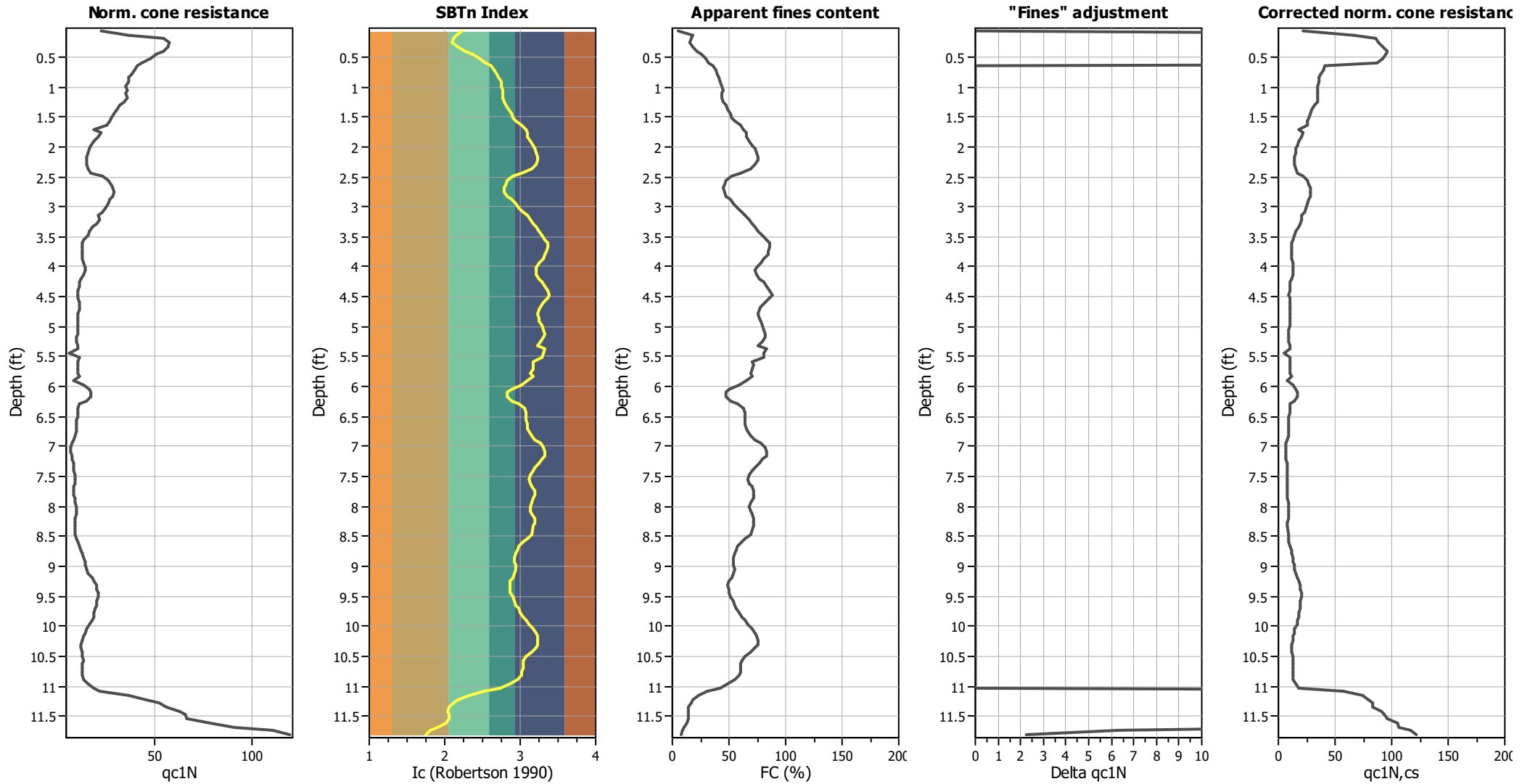
#### Input parameters and analysis data

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Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
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3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

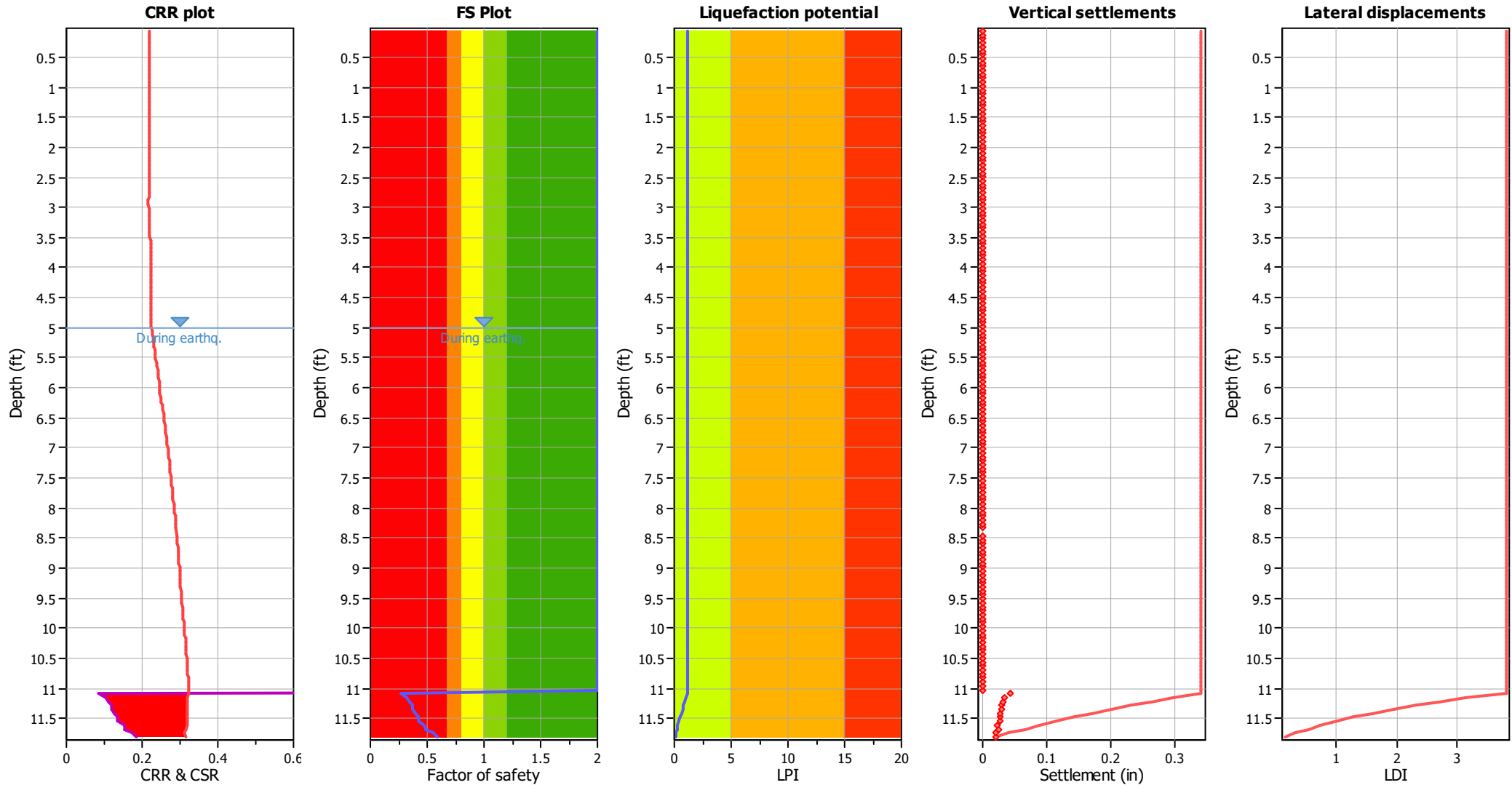
### Liquefaction analysis overall plots (intermediate results)



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

### Liquefaction analysis overall plots



**Input parameters and analysis data**

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Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

**F.S. color scheme**

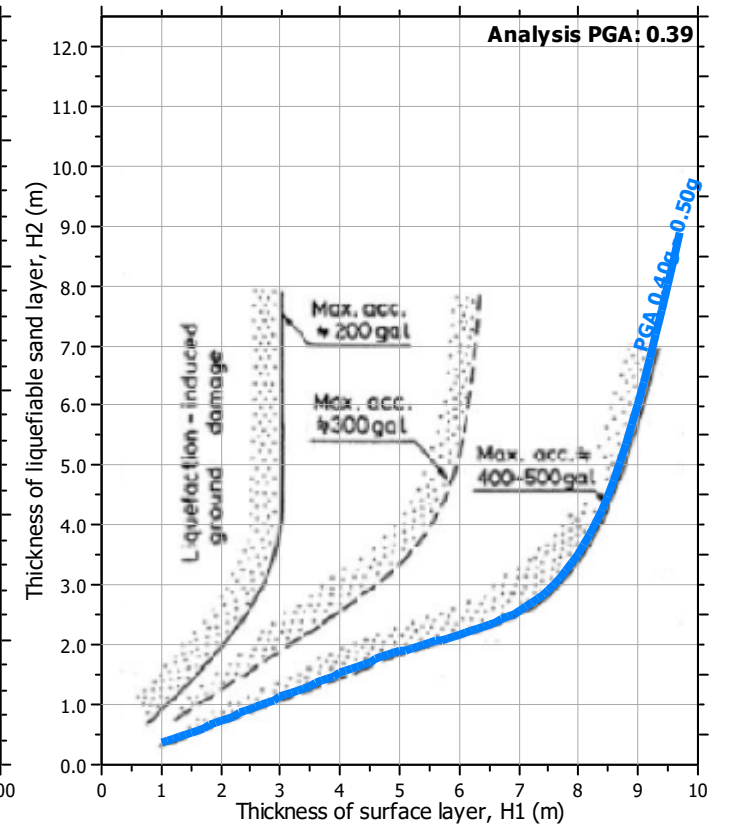
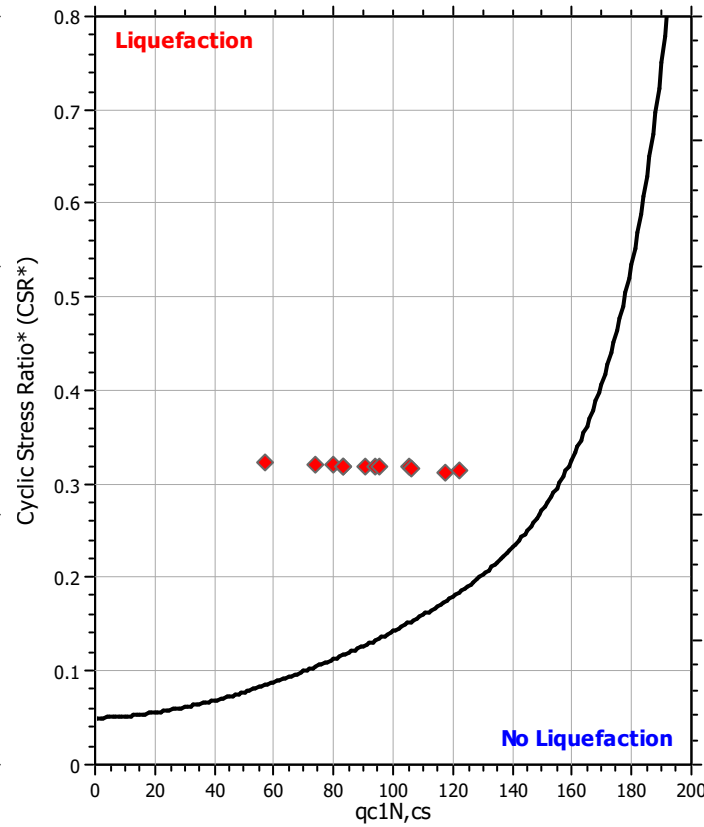
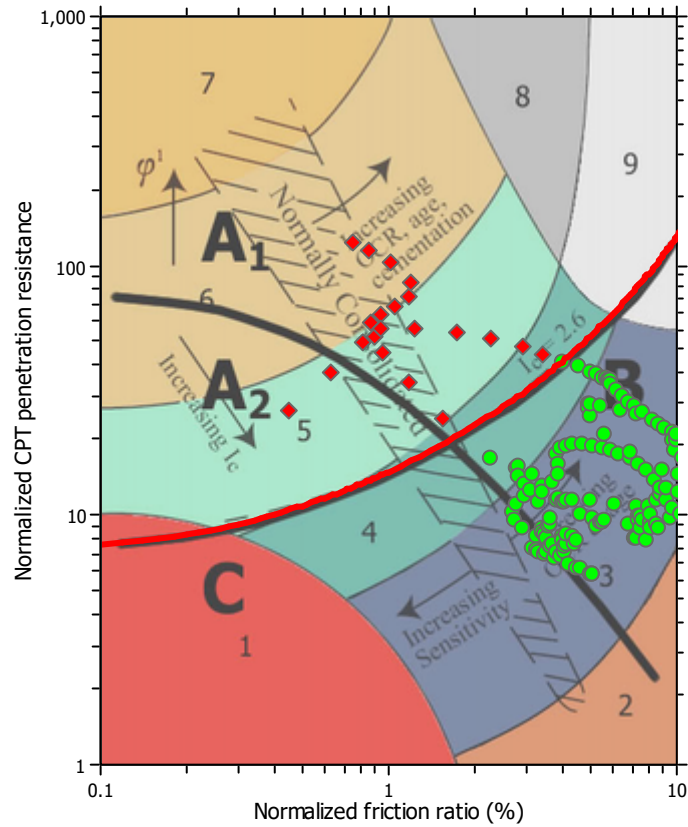
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk



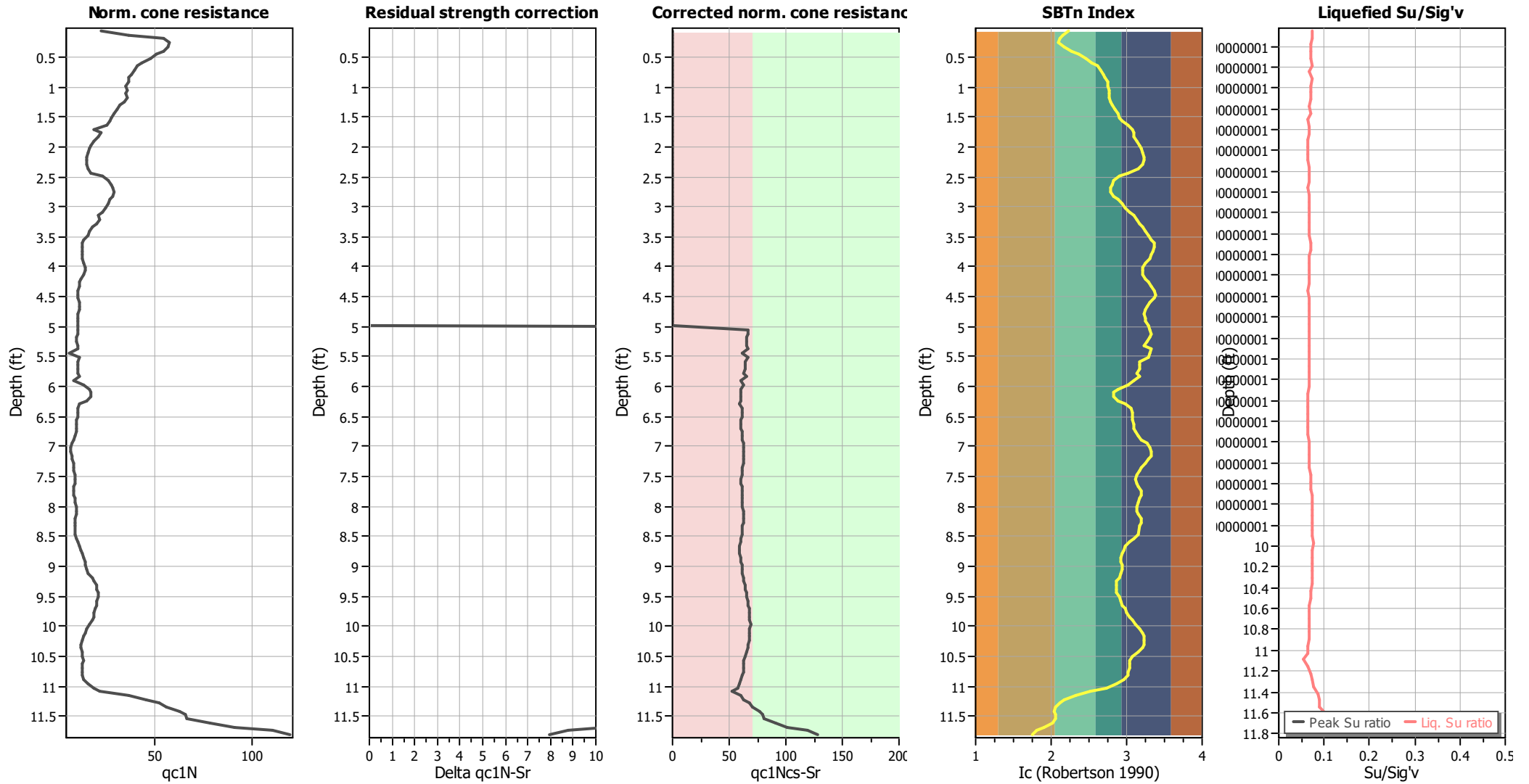
### Liquefaction analysis summary plots



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on $I_c$ value	$I_c$ cut-off value:	2.60	$K_{\phi}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

### Check for strength loss plots (Idriss & Boulanger (2008))



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

**LIQUEFACTION ANALYSIS REPORT**

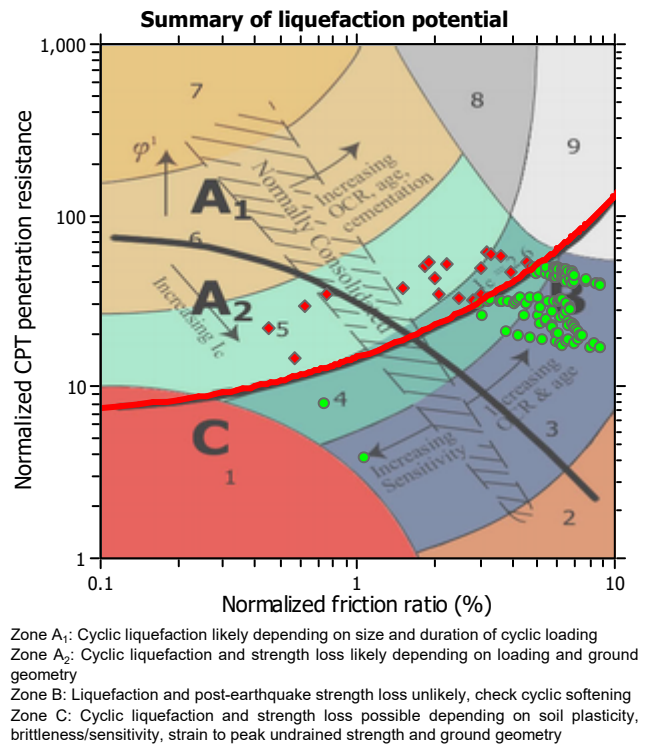
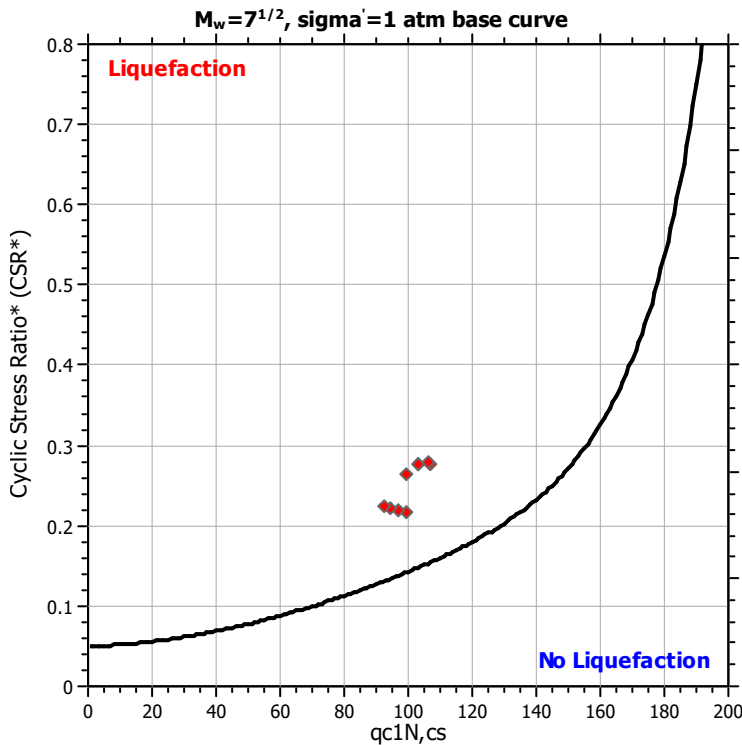
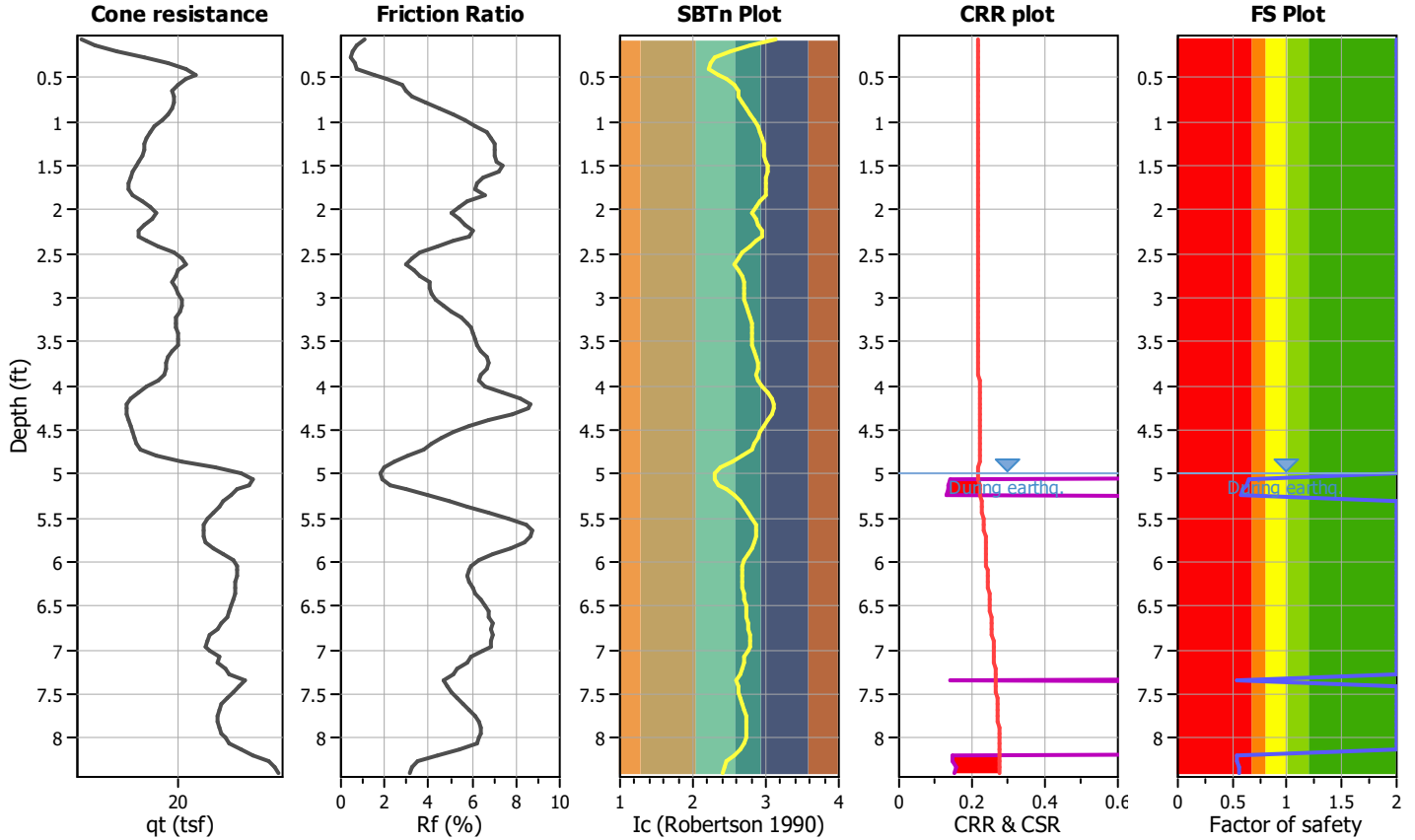
**Project title : CCR Ph 1**

**Location :**

**CPT file : CPT-8A**

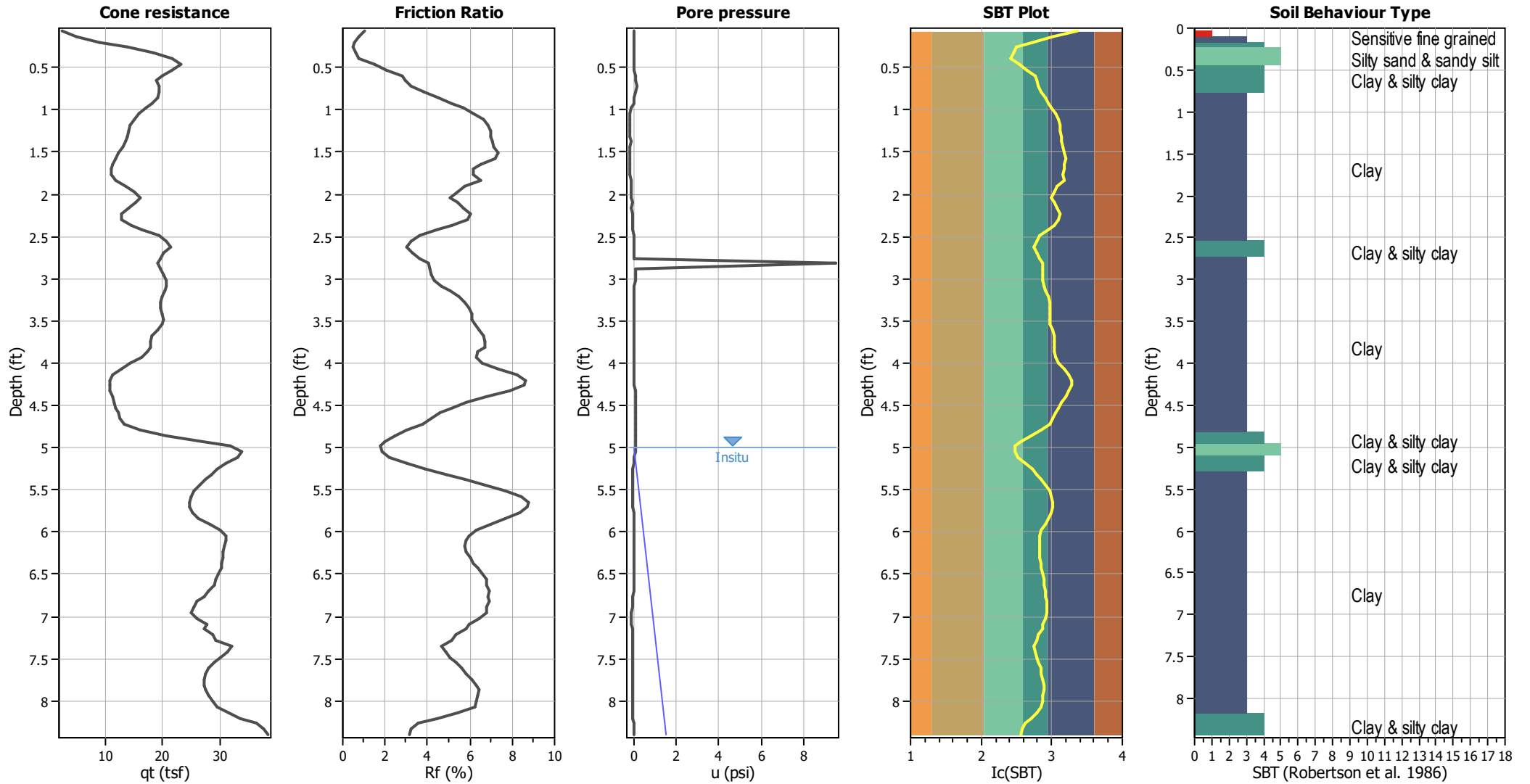
**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	5.00 ft	Use fill:	No	Clay like behavior	
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	5.00 ft	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.28	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.39	Unit weight calculation:	Based on SBT	$K_f$ applied:	Yes	MSF method:	Method





### CPT basic interpretation plots



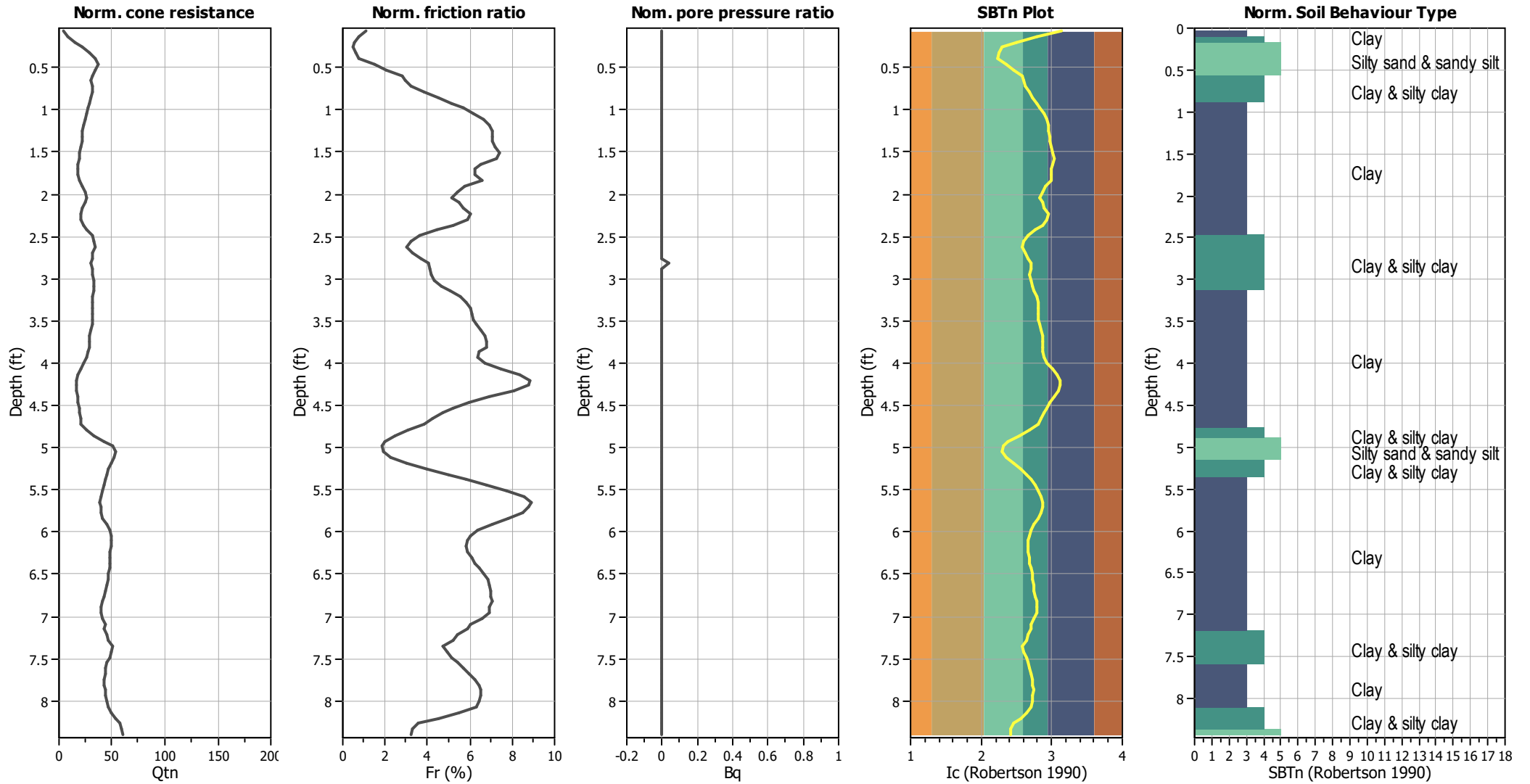
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
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#### SBT legend

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### CPT basic interpretation plots (normalized)



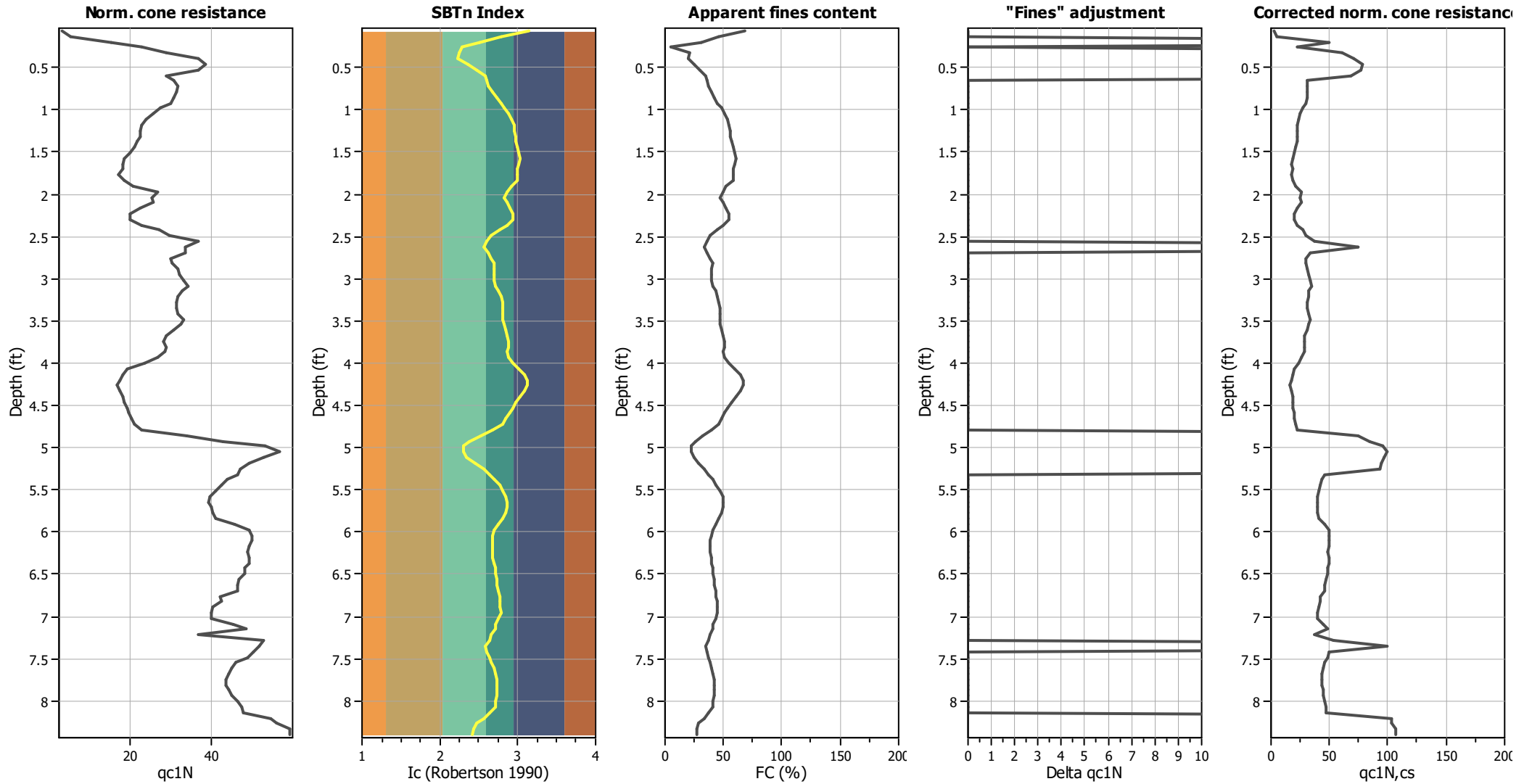
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Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
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### Liquefaction analysis overall plots (intermediate results)

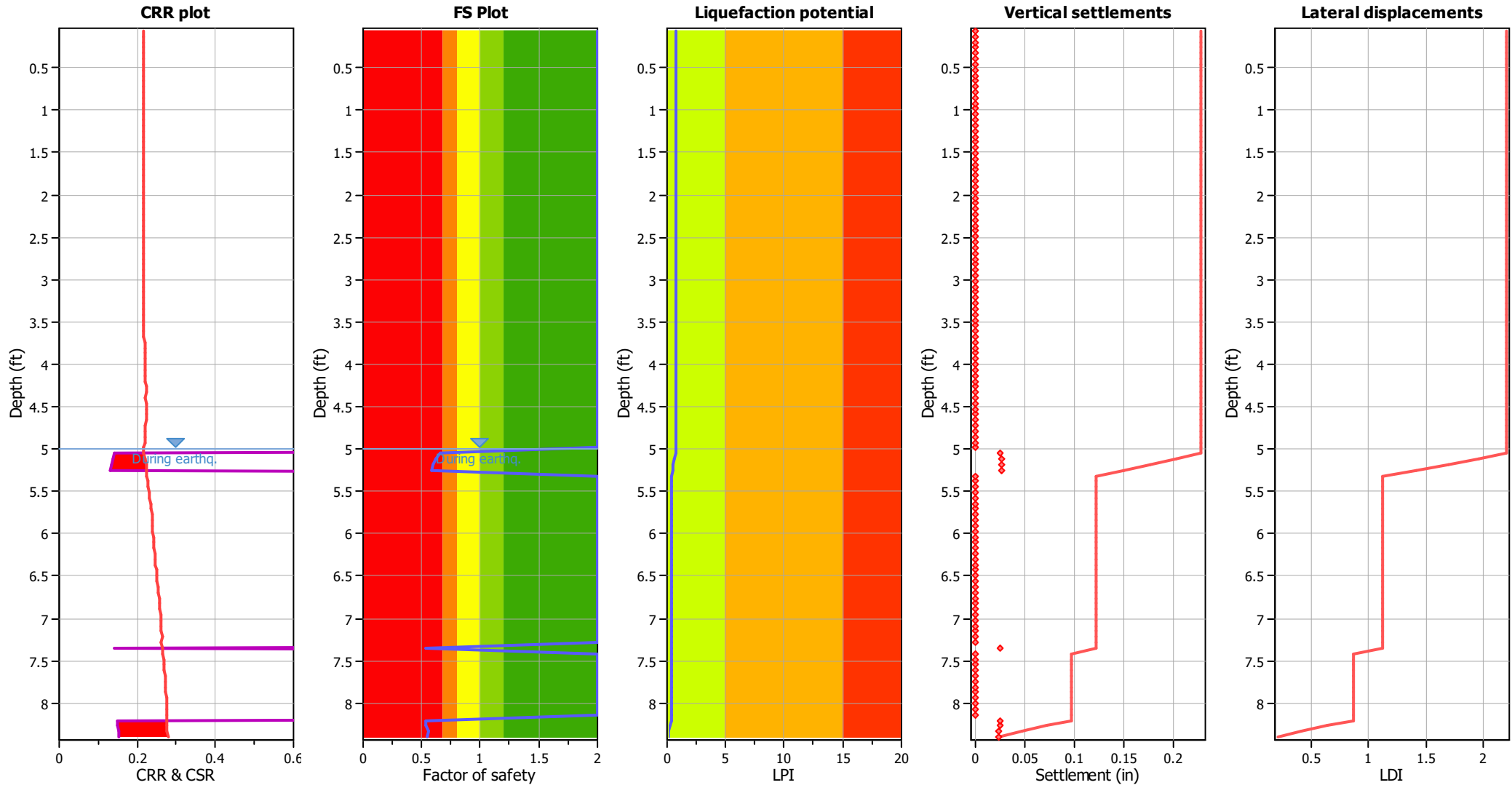


**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
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Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
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### Liquefaction analysis overall plots



**Input parameters and analysis data**

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Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
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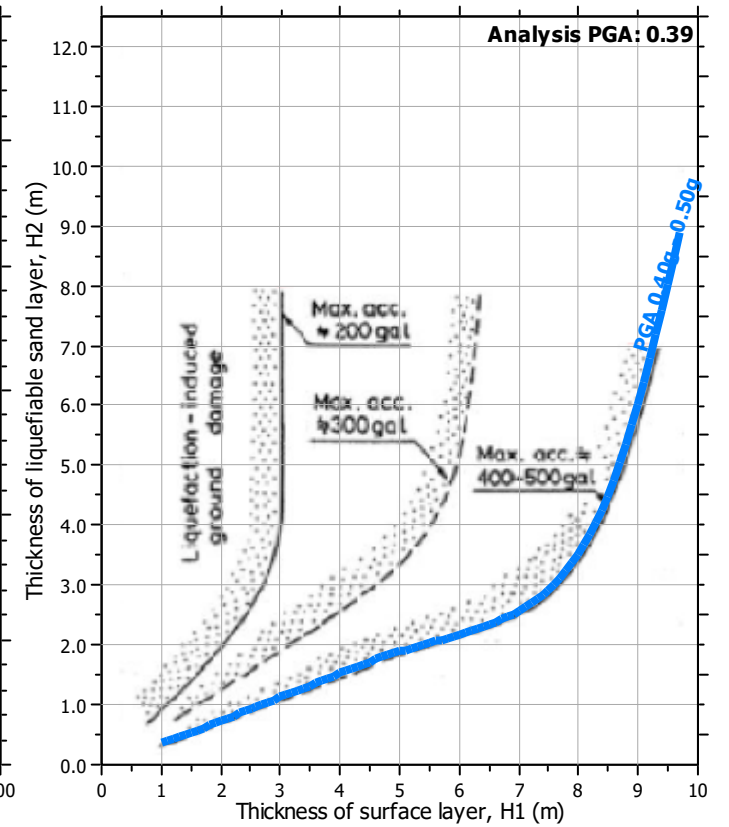
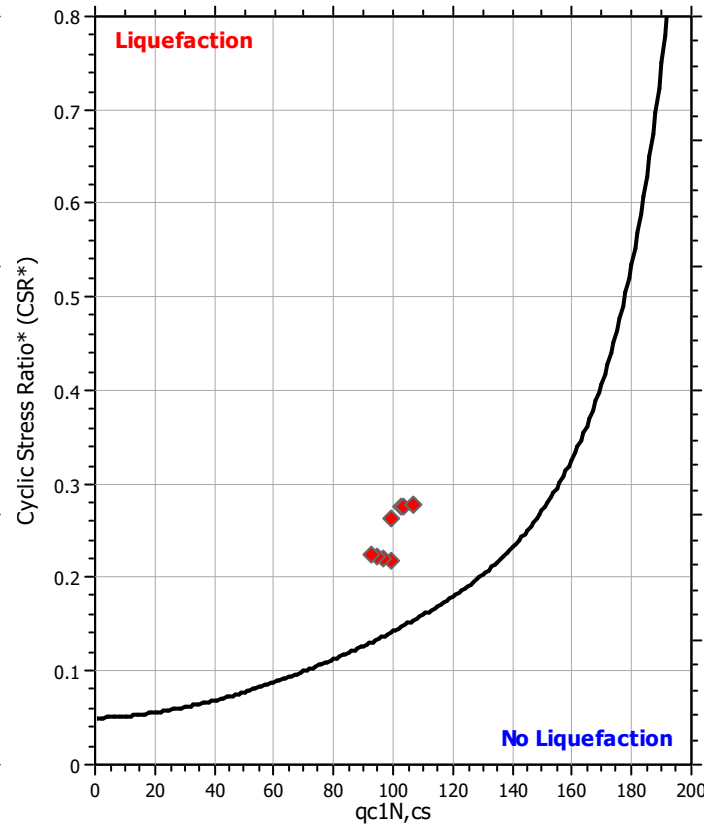
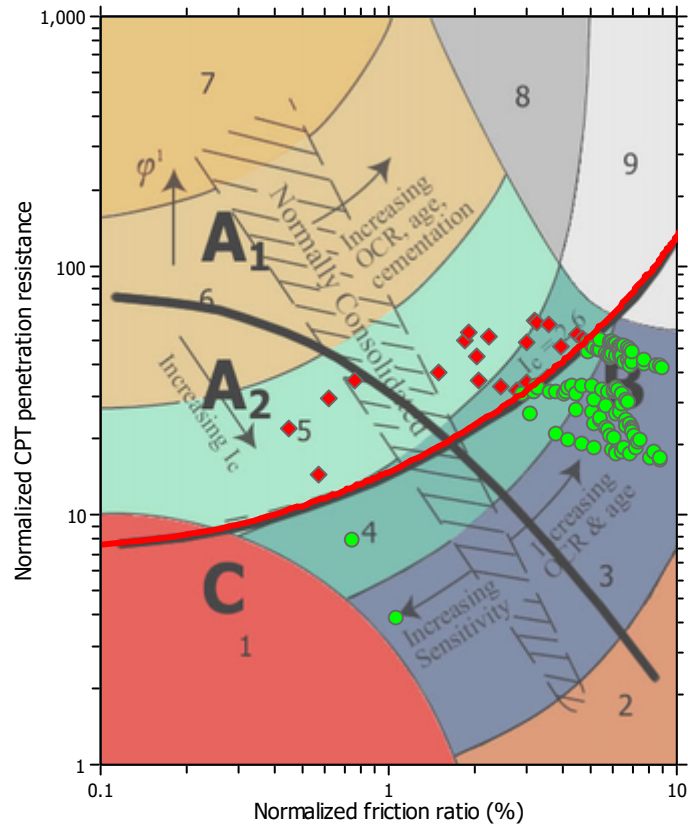
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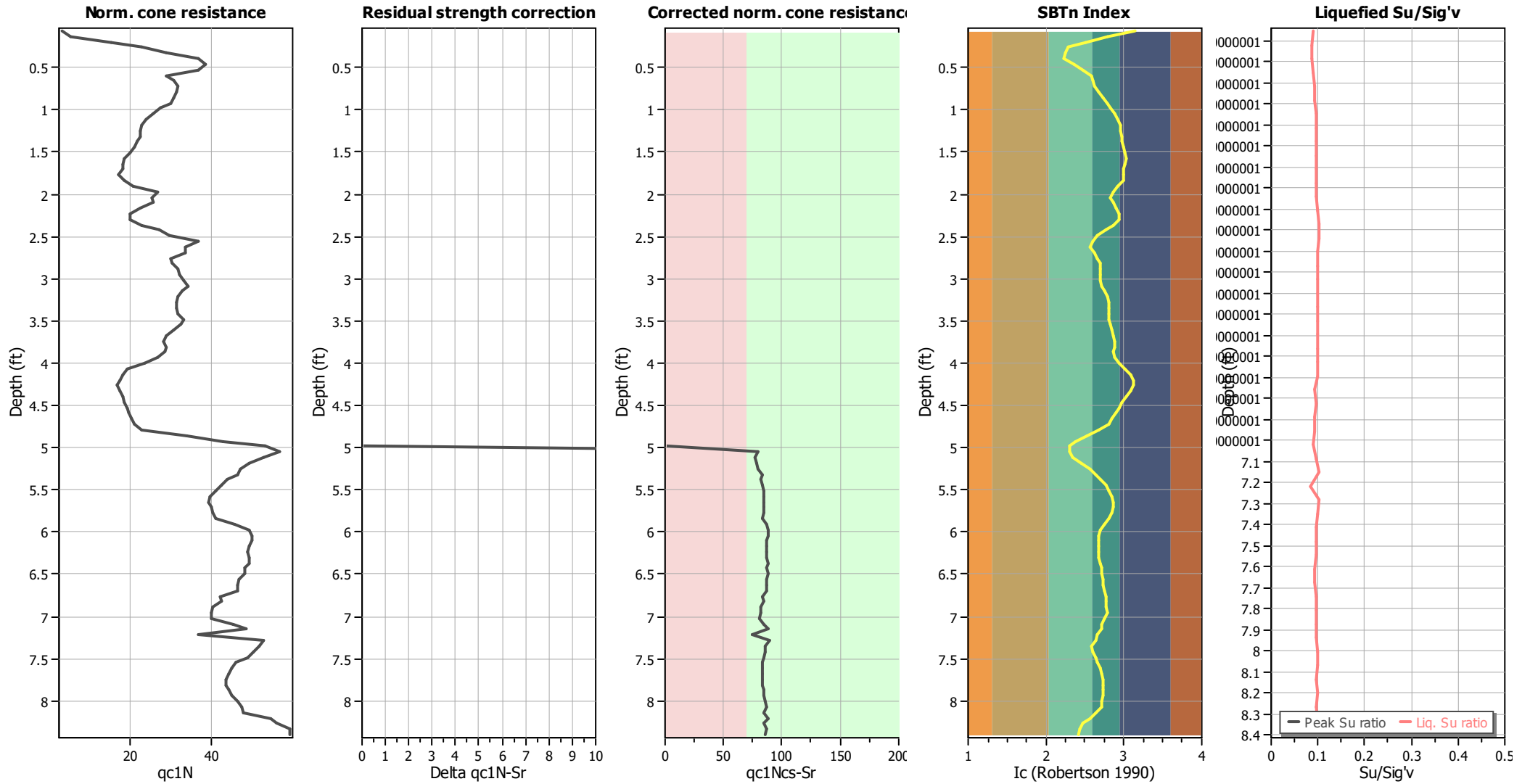
### Liquefaction analysis summary plots



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Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
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**LIQUEFACTION ANALYSIS REPORT**

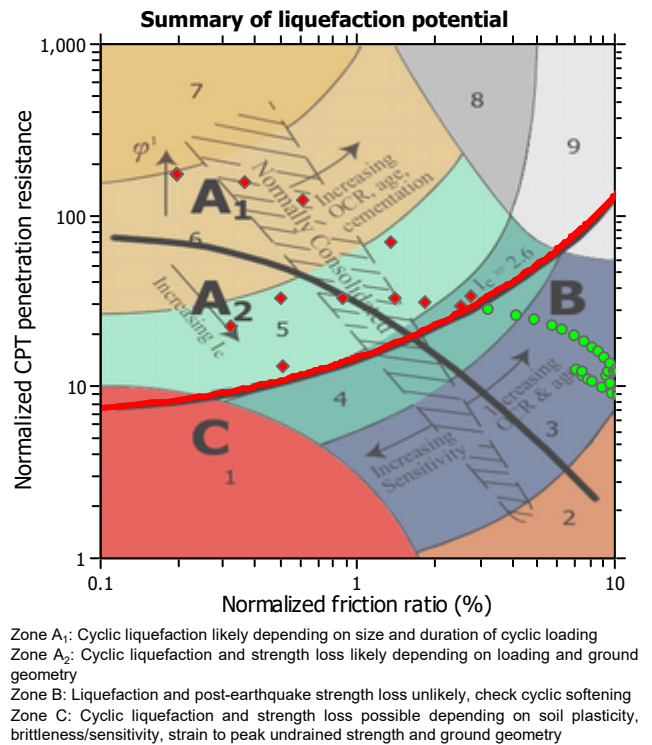
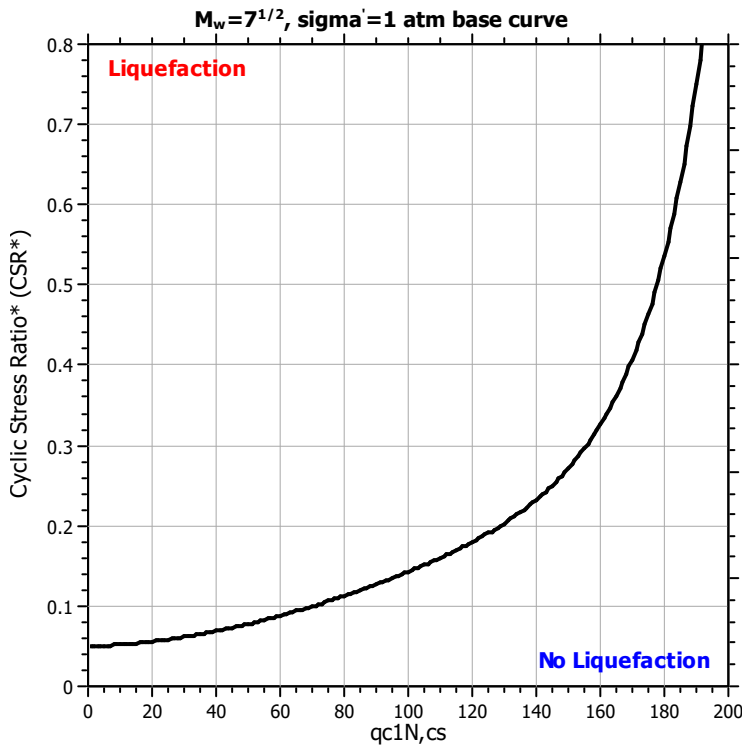
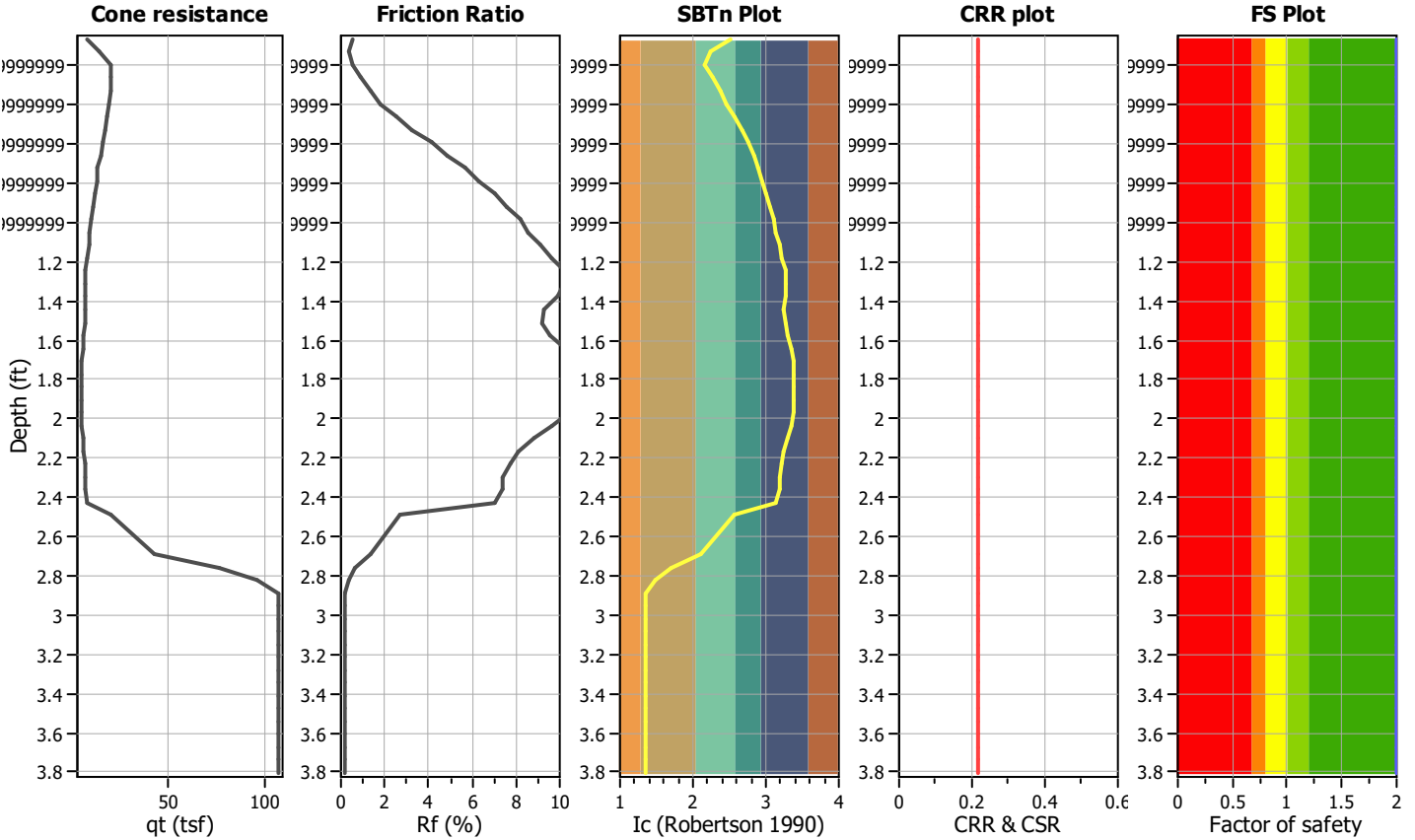
**Project title : CCR Ph 1**

**Location :**

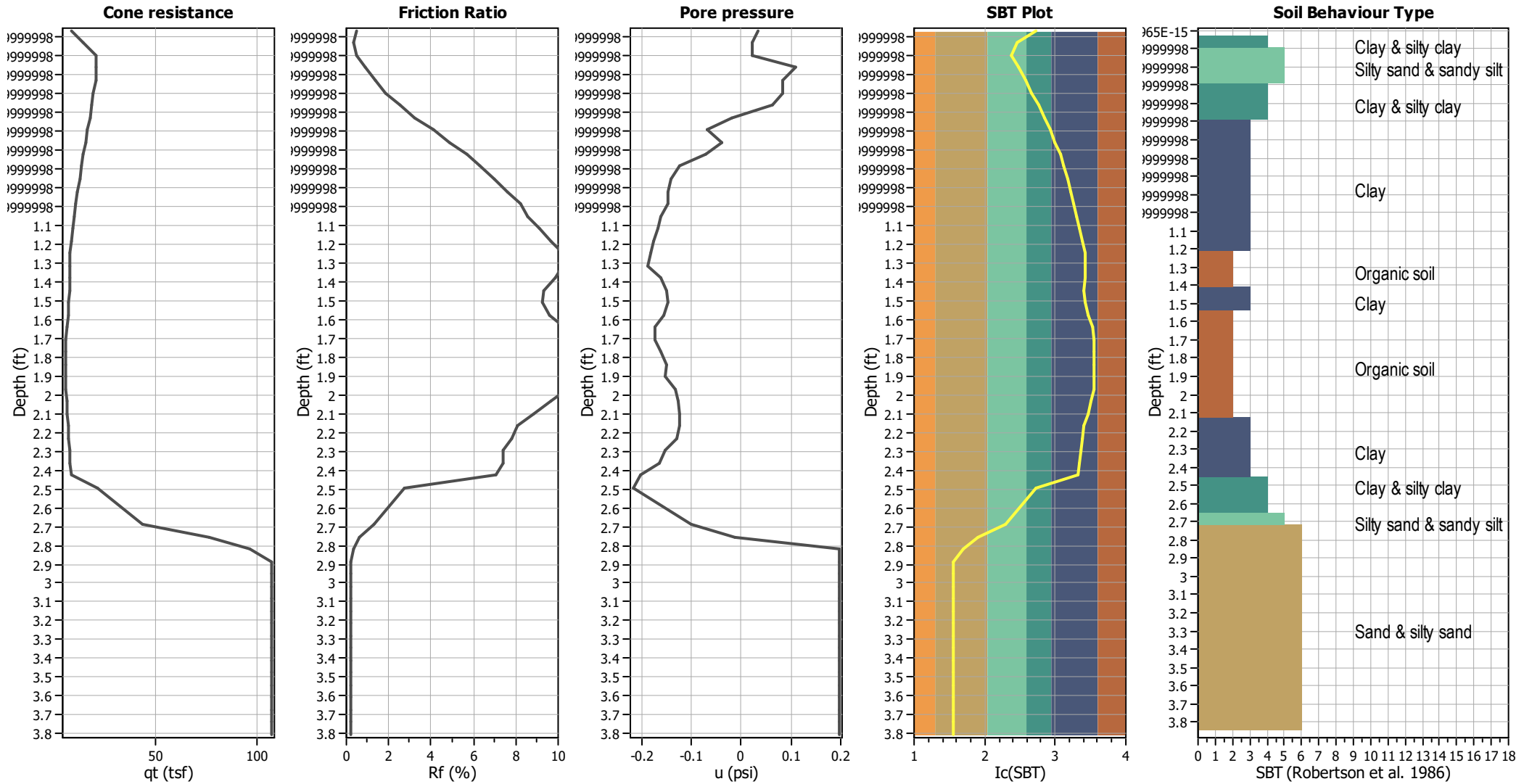
**CPT file : CPT-9A**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	5.00 ft	Use fill:	No	Clay like behavior	
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	5.00 ft	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.28	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.39	Unit weight calculation:	Based on SBT	$K_f$ applied:	Yes	MSF method:	Method



### CPT basic interpretation plots



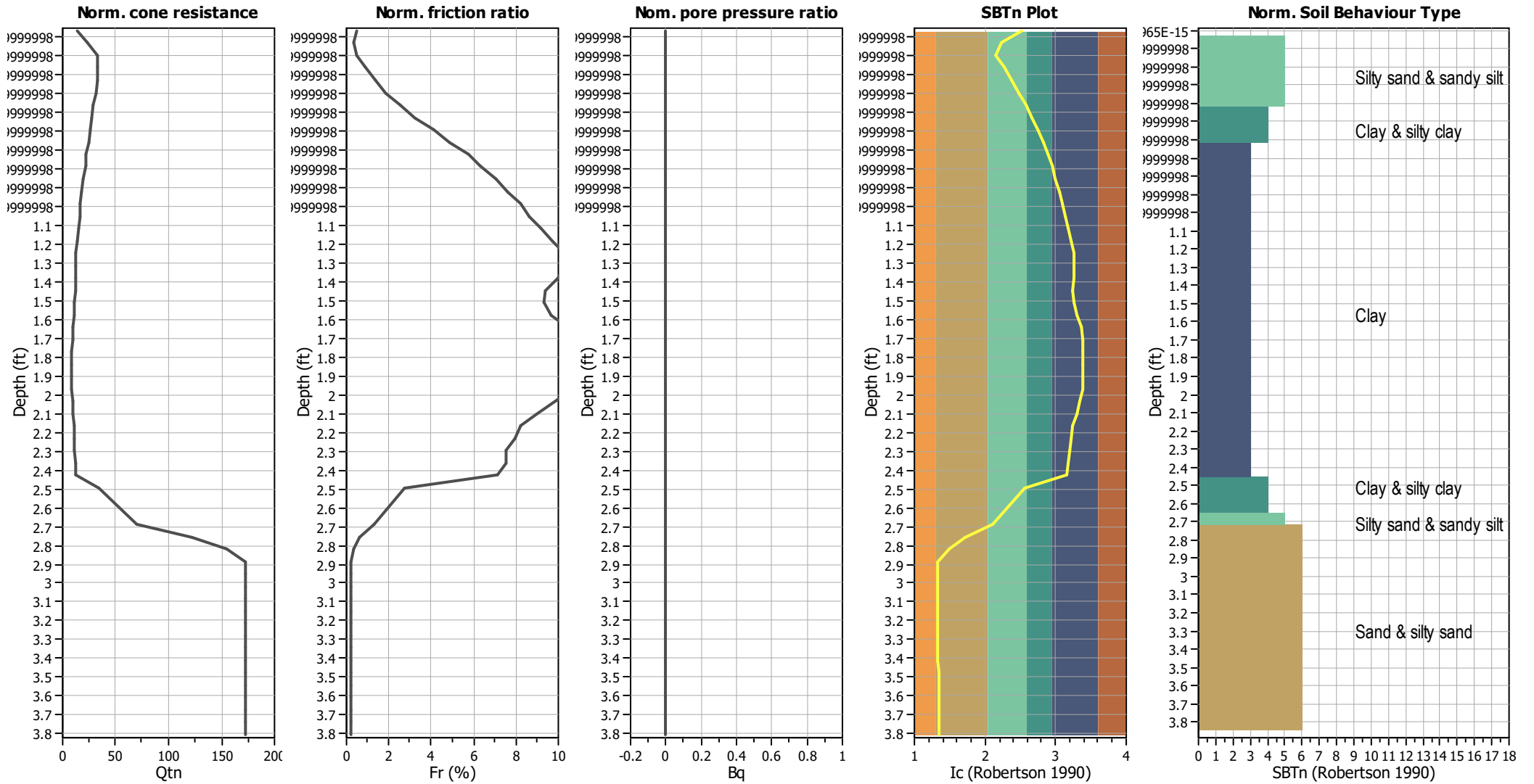
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

#### SBT legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

### CPT basic interpretation plots (normalized)



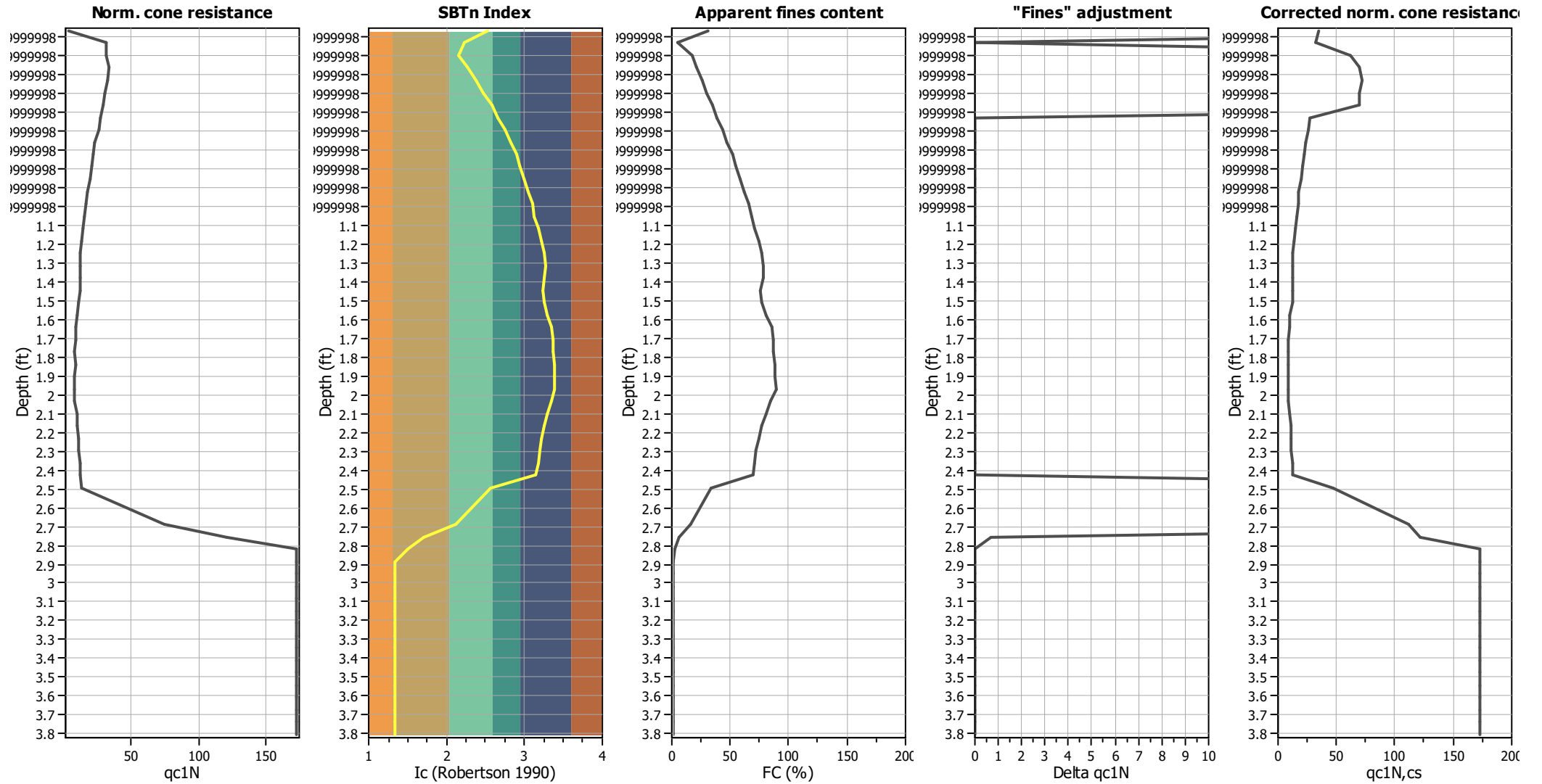
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

### Liquefaction analysis overall plots (intermediate results)

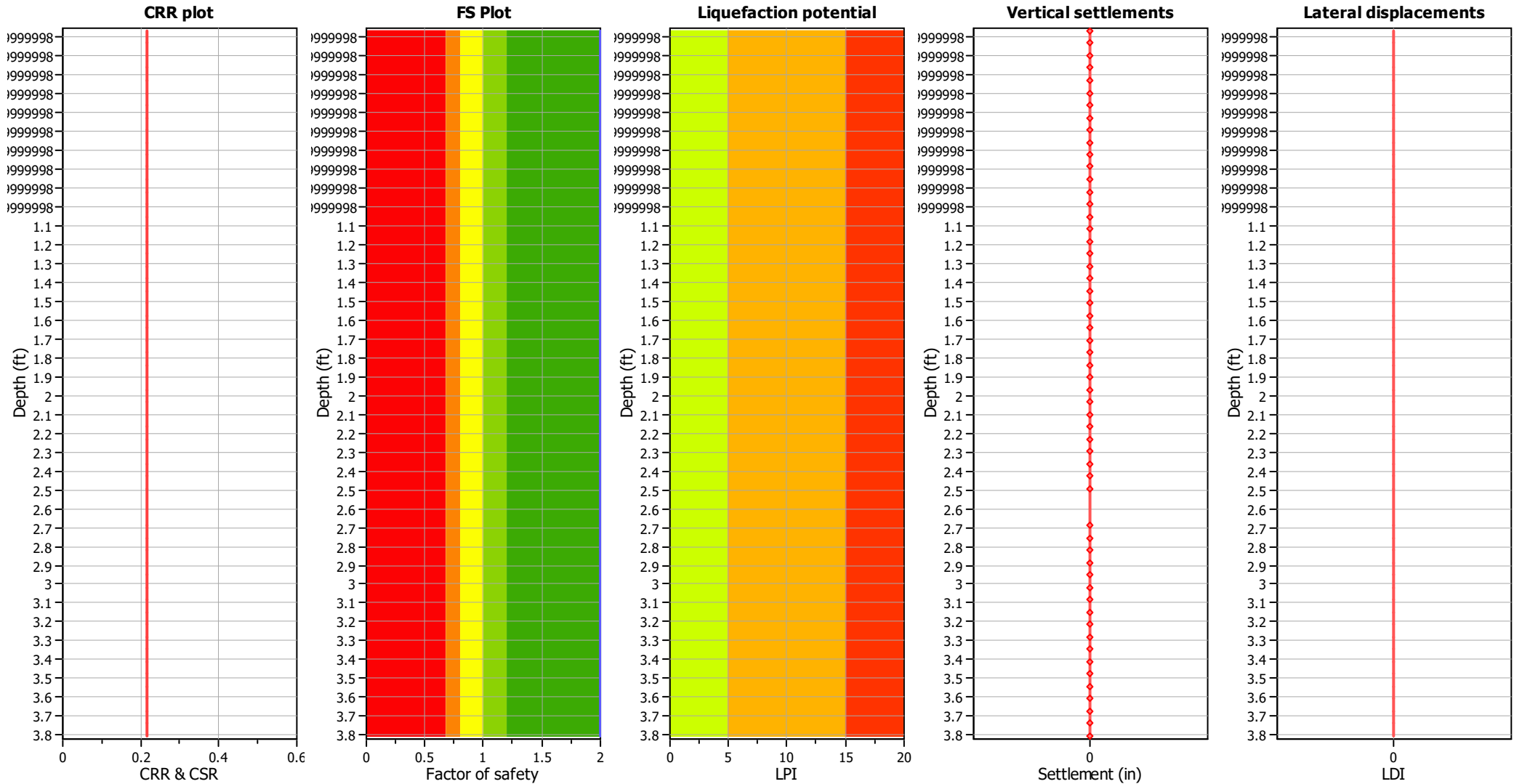


#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_p$ applied:	Yes
Earthquake magnitude $M_w$ :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A



### Liquefaction analysis overall plots



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

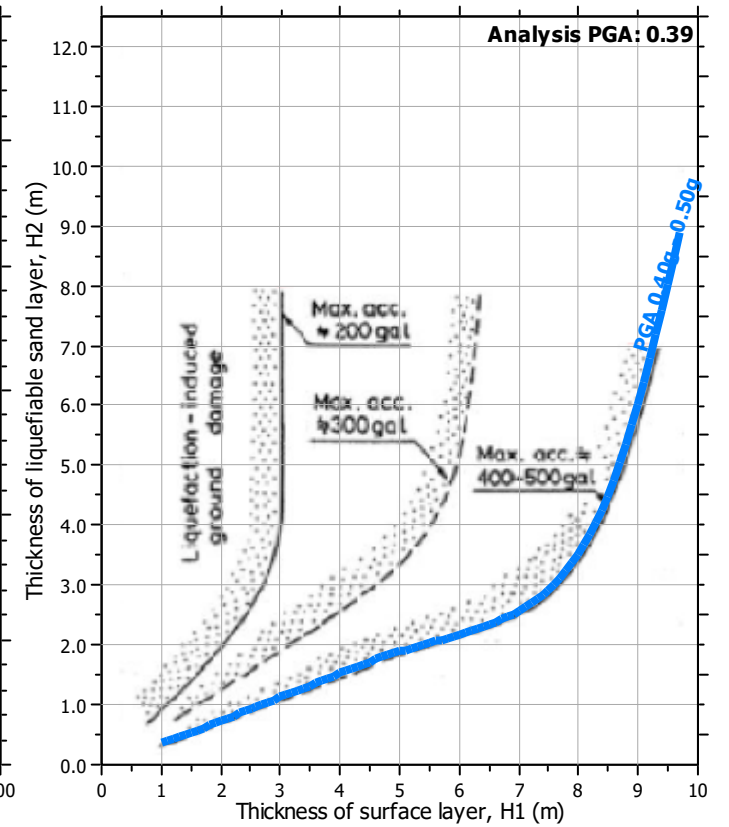
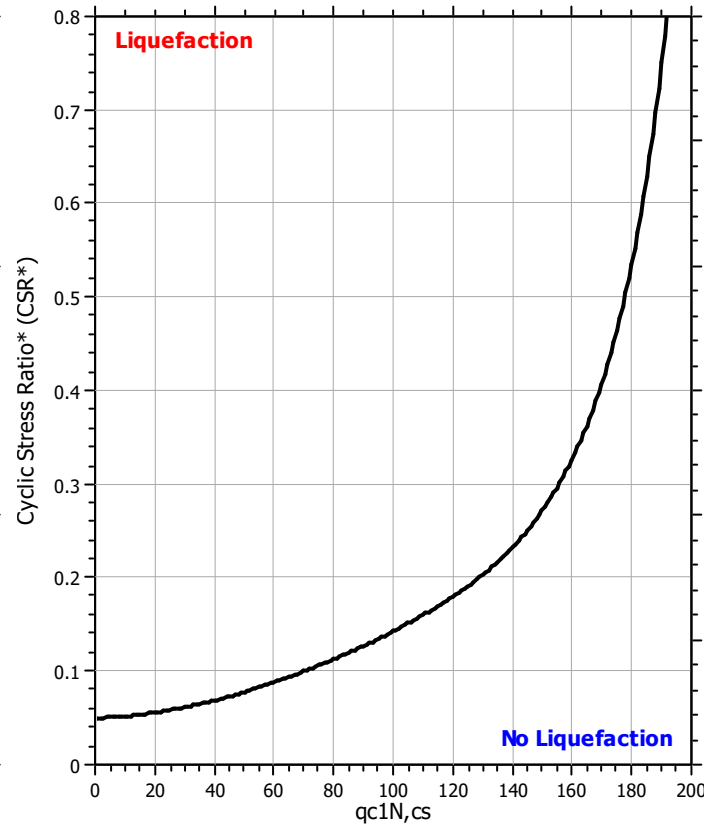
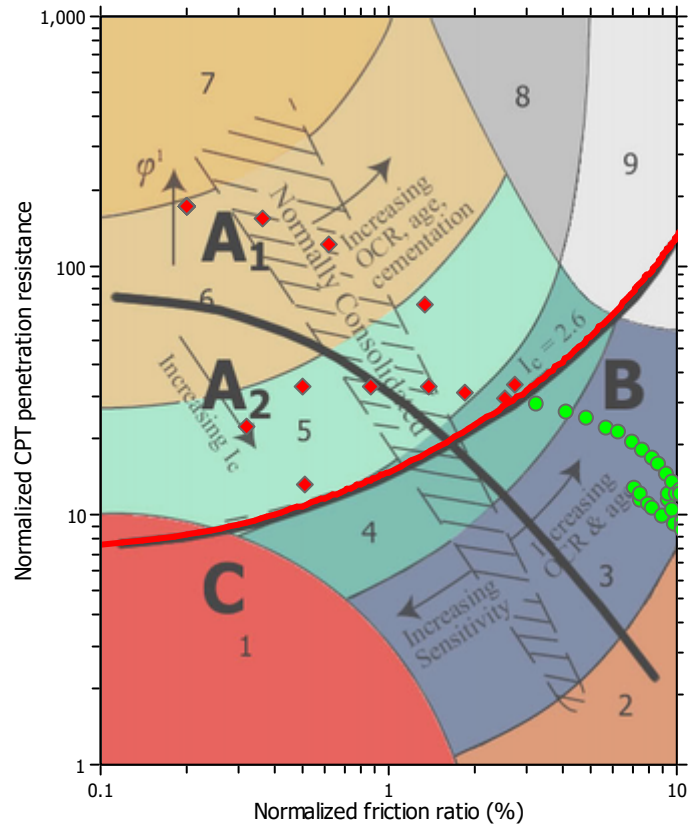
#### F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

#### LPI color scheme

- Very high risk
- High risk
- Low risk

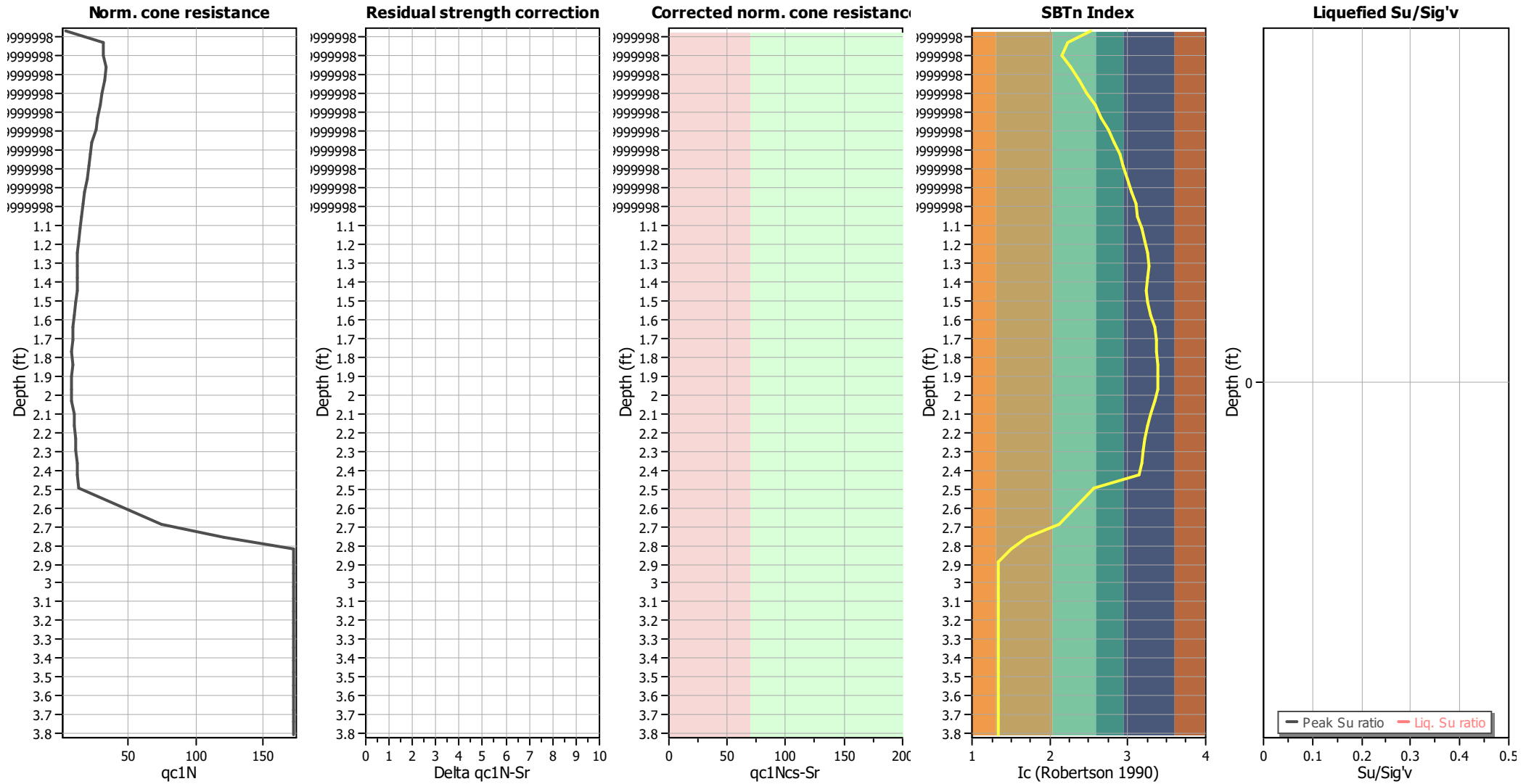
### Liquefaction analysis summary plots



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on I <sub>c</sub> value	I <sub>c</sub> cut-off value:	2.60	K <sub>0</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

### Check for strength loss plots (Idriss & Boulanger (2008))



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

**LIQUEFACTION ANALYSIS REPORT**

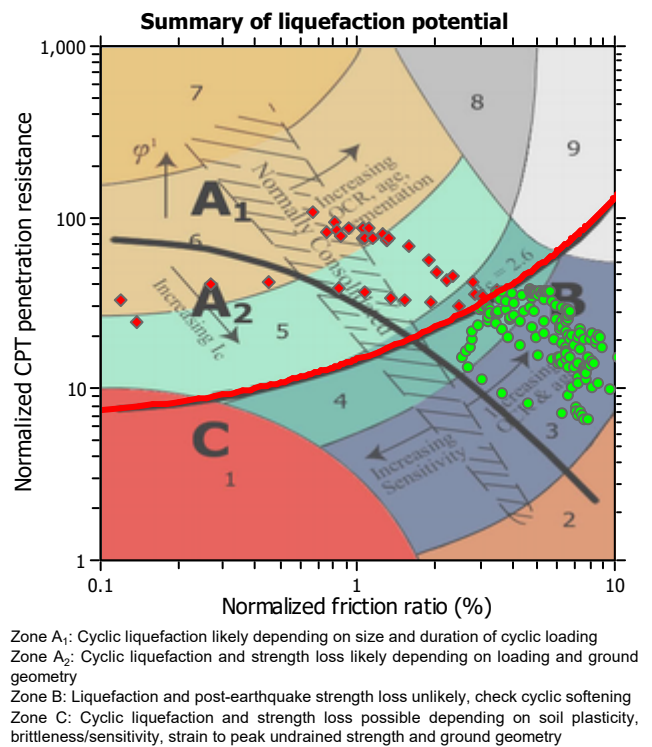
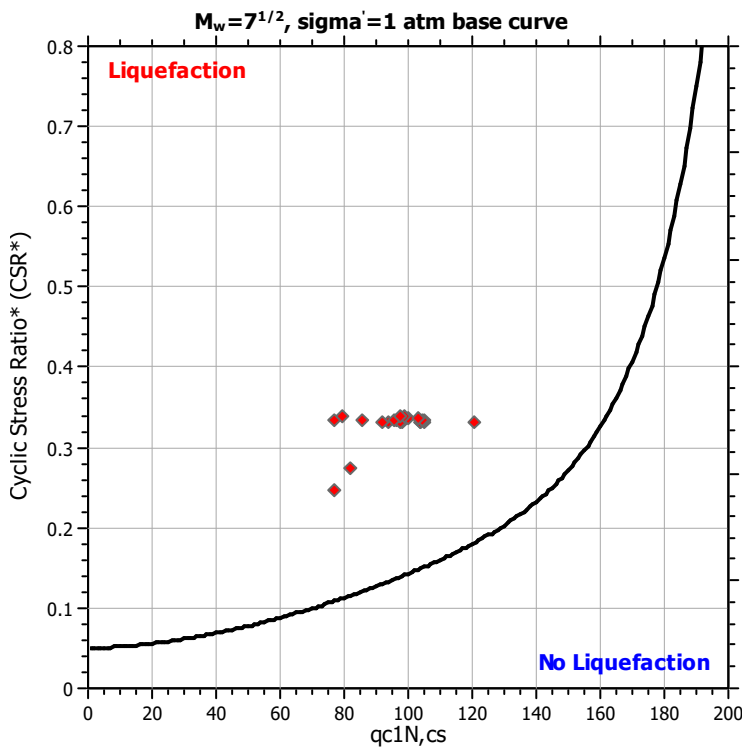
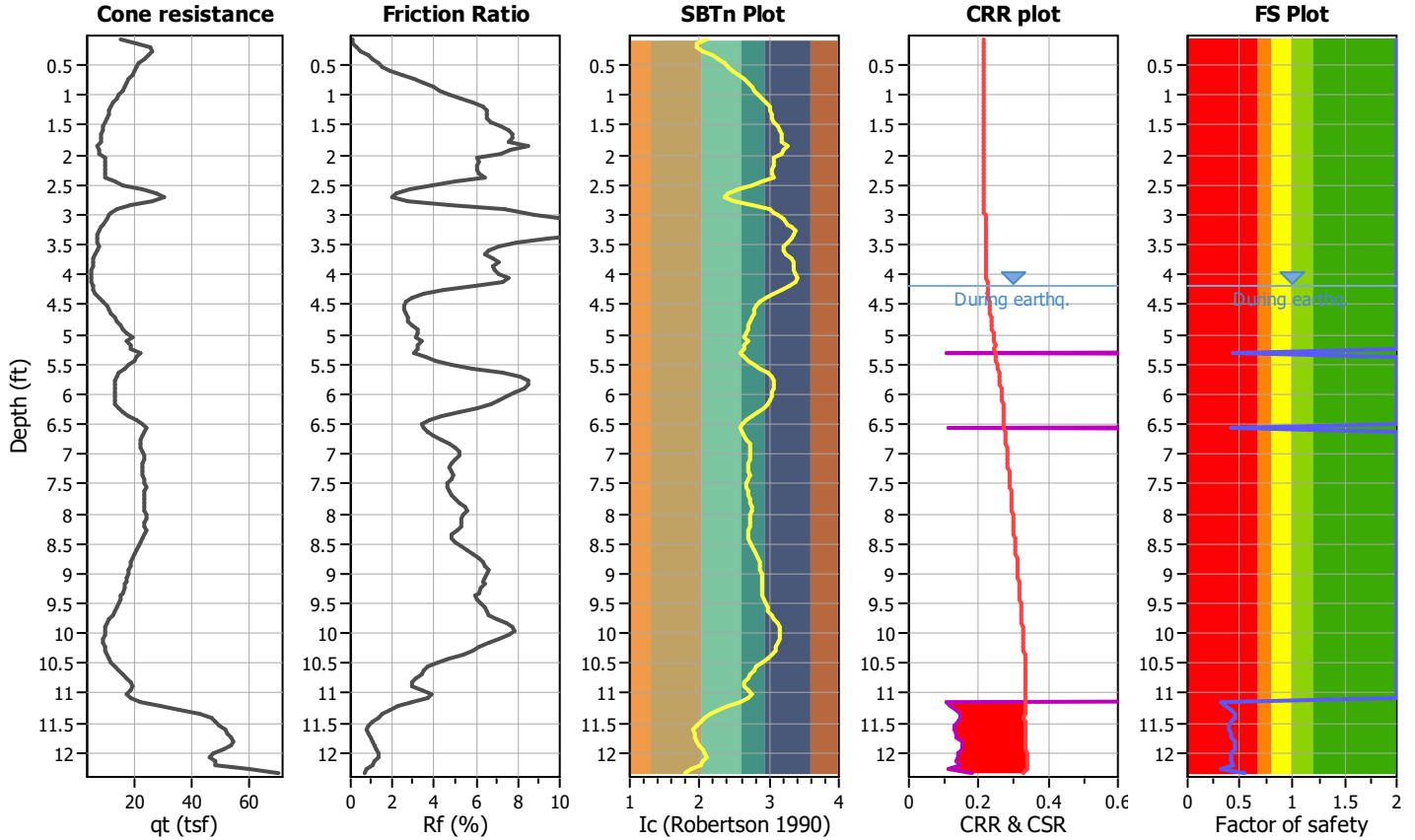
**Project title : CCR Ph 1**

**Location :**

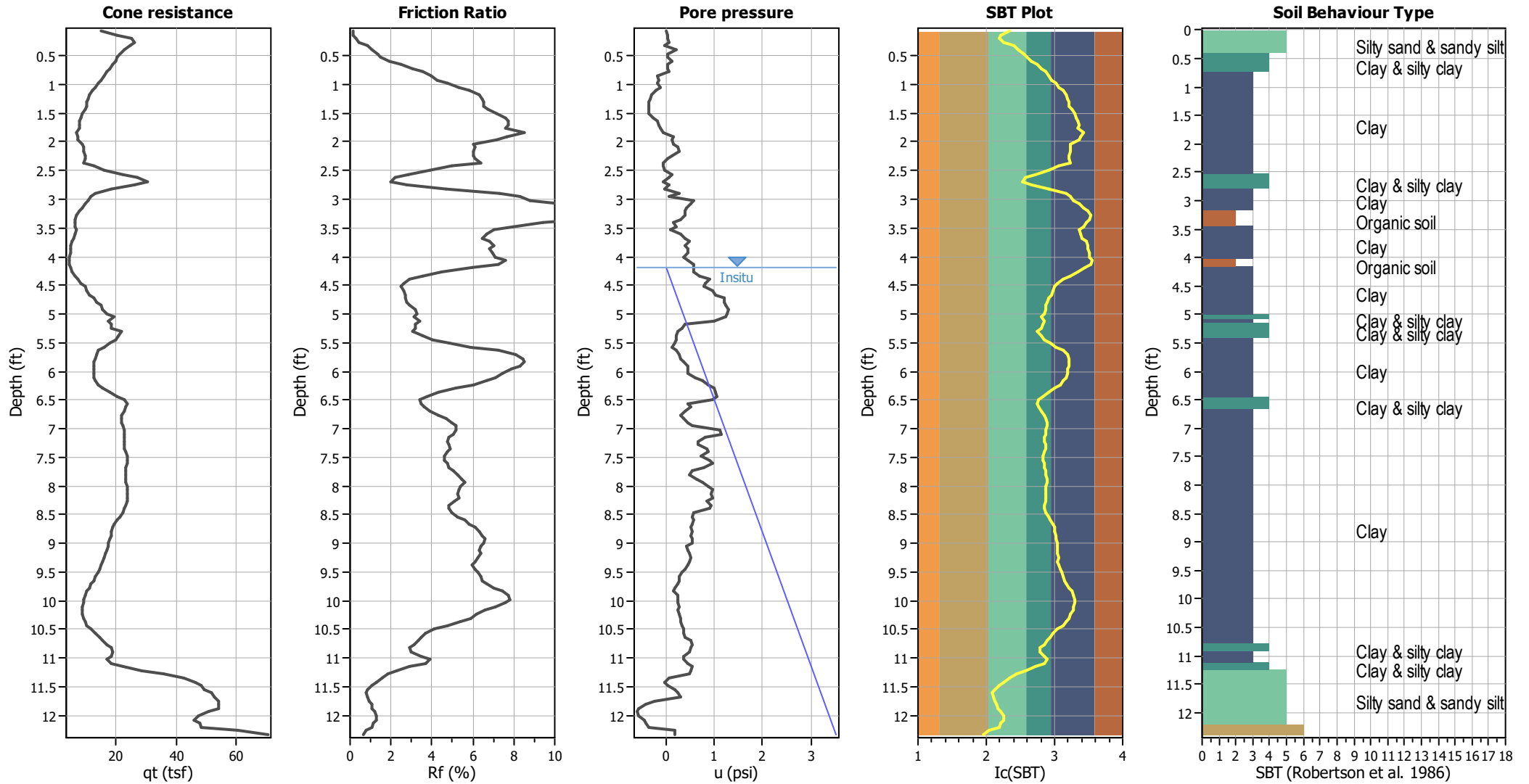
**CPT file : CPT-10B**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	4.20 ft	Use fill:	No	Clay like behavior	
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	4.20 ft	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.28	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.39	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes	MSF method:	Method



### CPT basic interpretation plots



#### Input parameters and analysis data

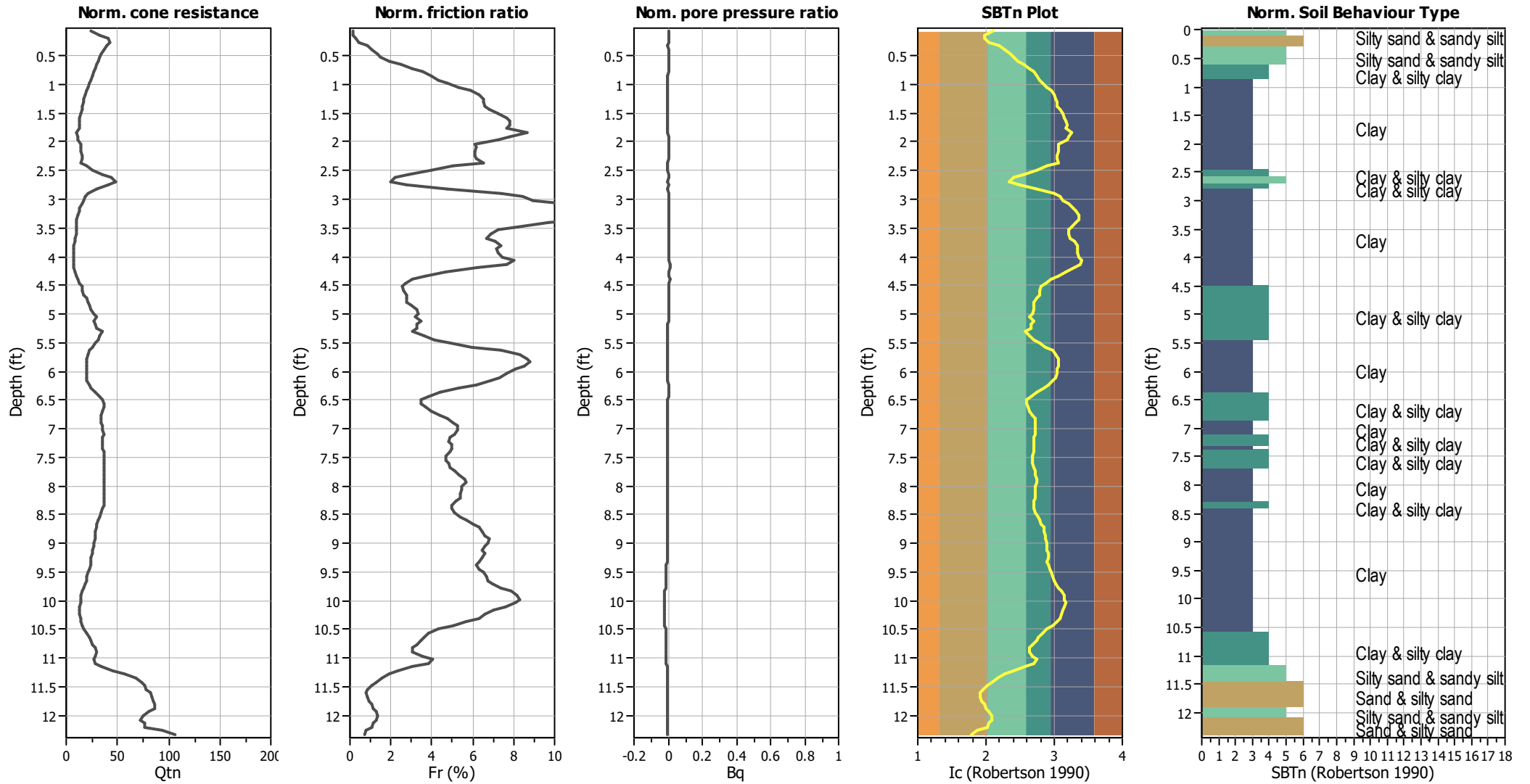
Analysis method:	I&B (2008)	Depth to GWT (erthq.):	4.20 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.20 ft	Fill height:	N/A	Limit depth:	N/A

#### SBT legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained



### CPT basic interpretation plots (normalized)



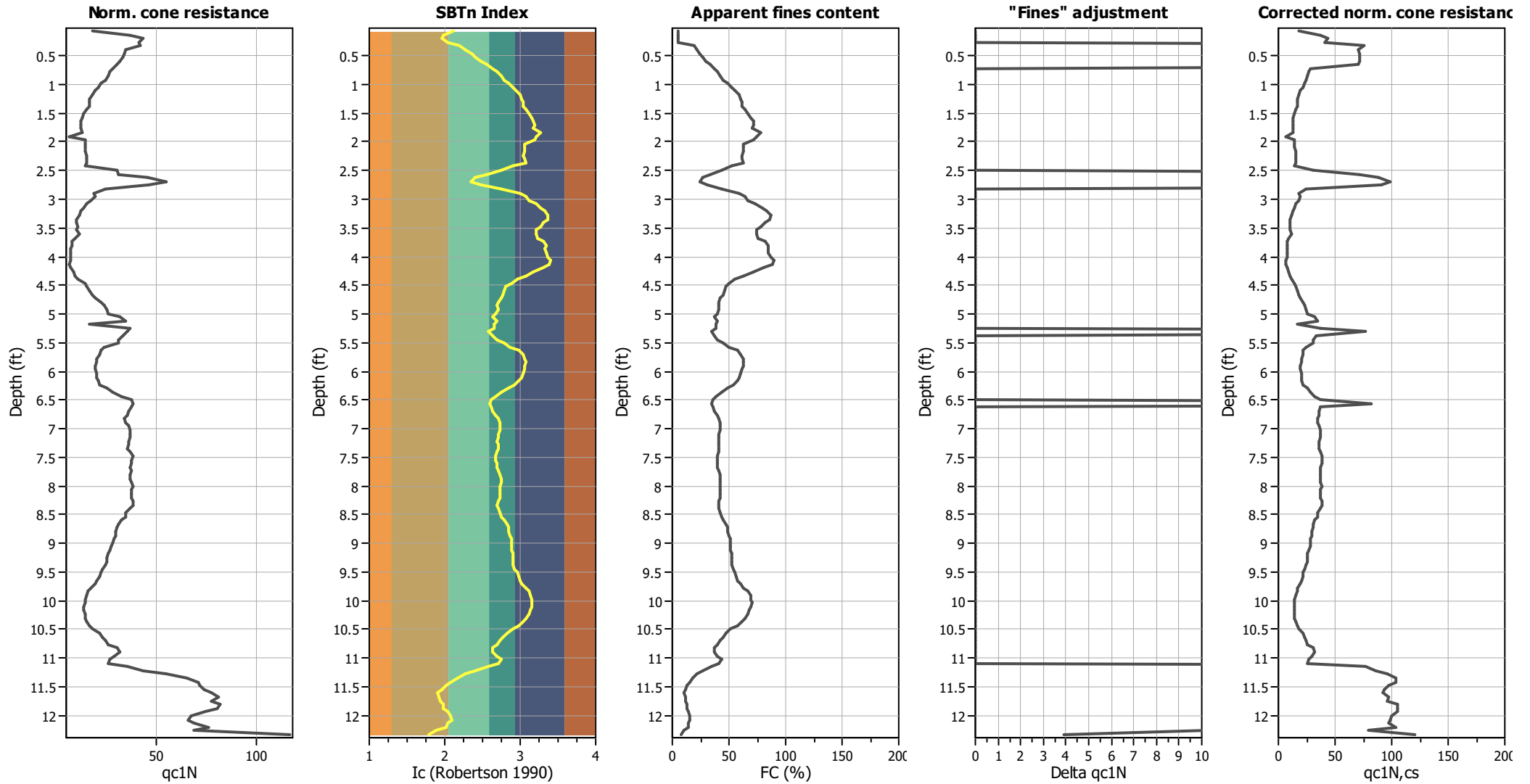
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	4.20 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.20 ft	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

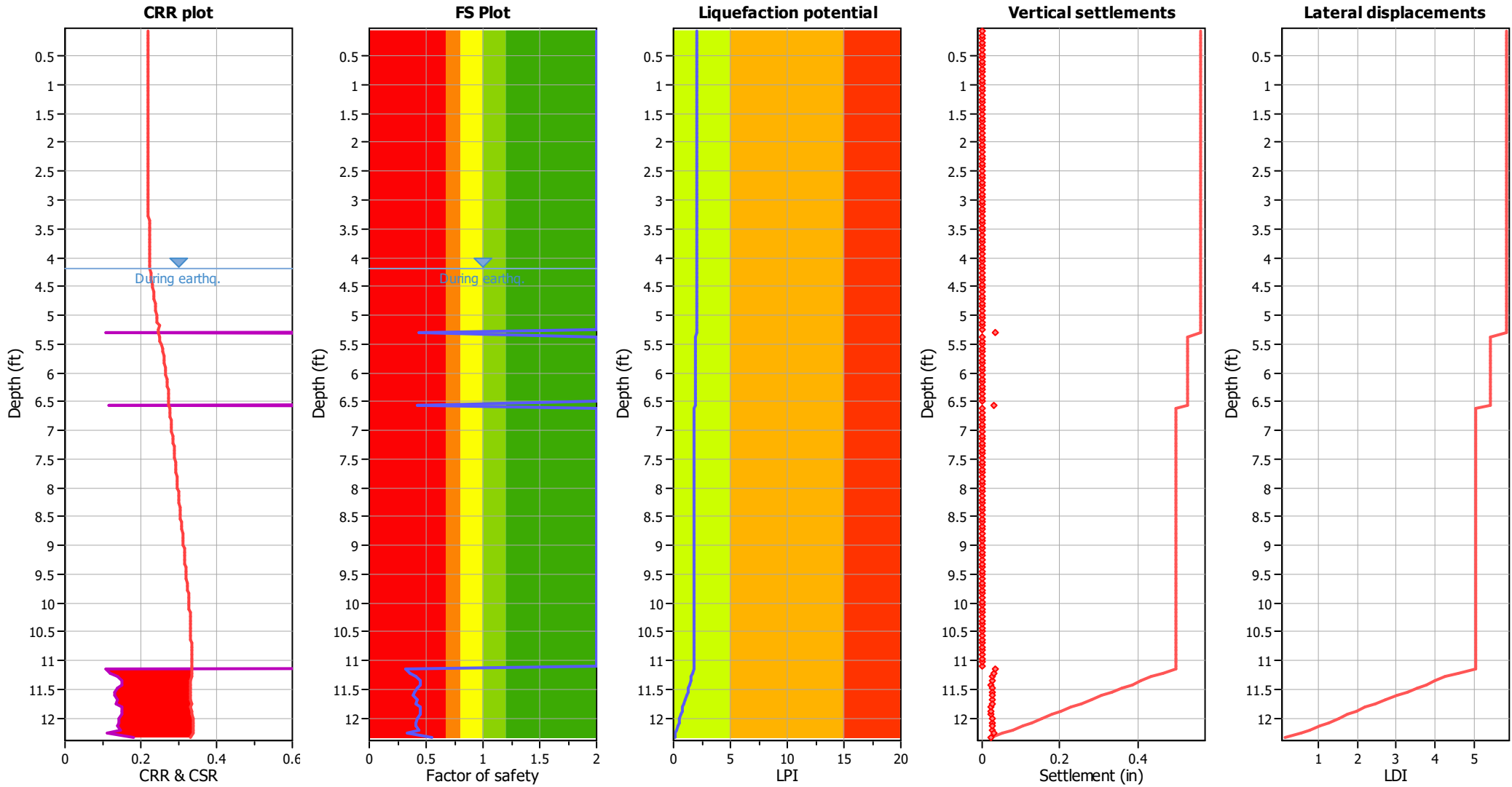
### Liquefaction analysis overall plots (intermediate results)



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	4.20 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.20 ft	Fill height:	N/A	Limit depth:	N/A

### Liquefaction analysis overall plots



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	4.20 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_d$ applied:	Yes
Earthquake magnitude $M_w$ :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.20 ft	Fill height:	N/A	Limit depth:	N/A

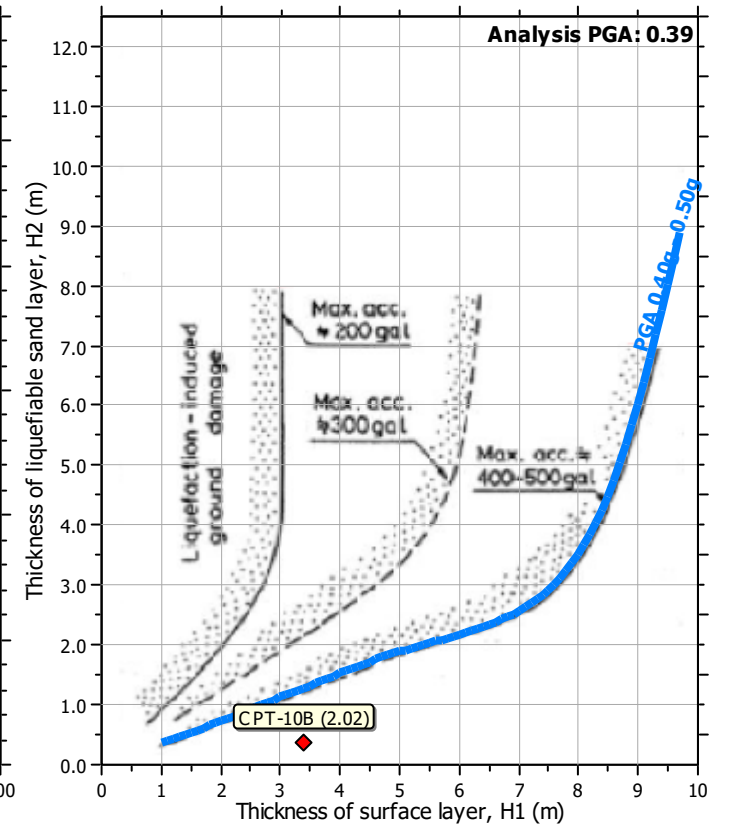
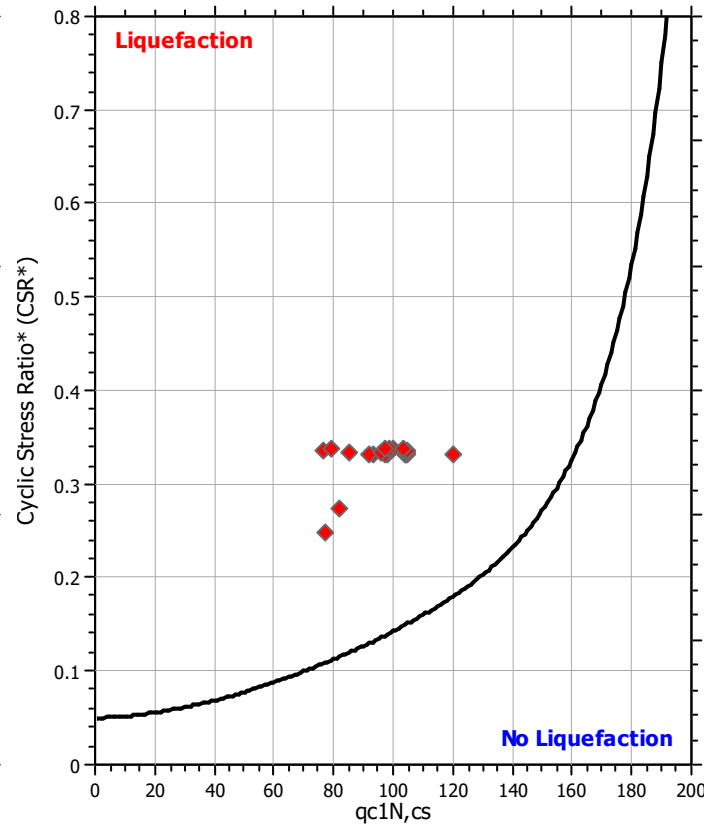
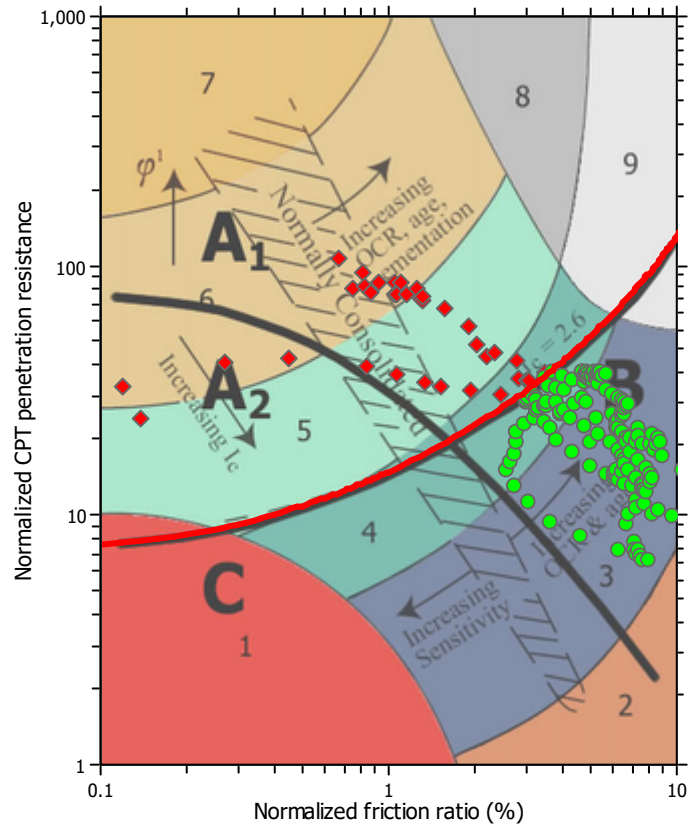
**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

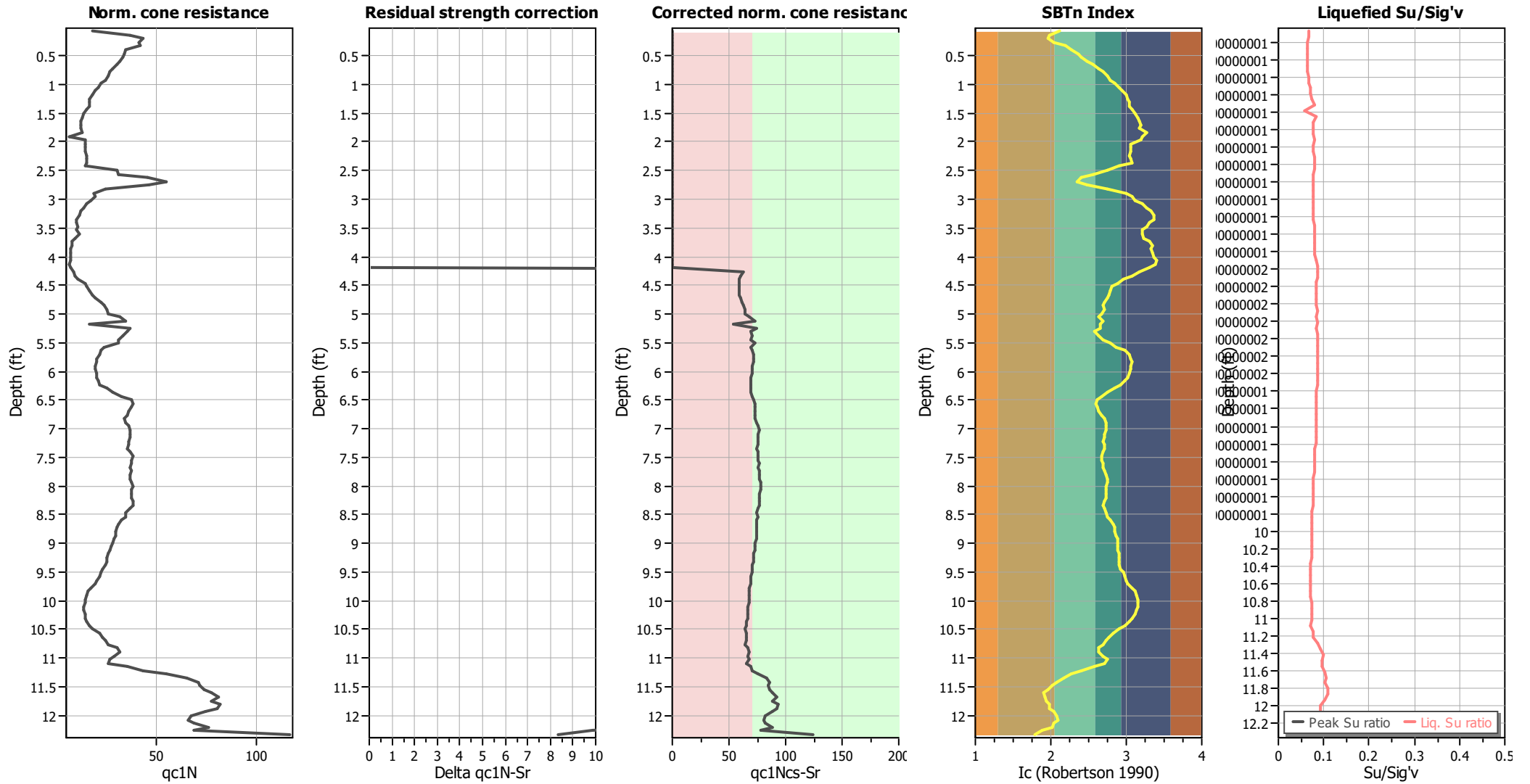
### Liquefaction analysis summary plots



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	4.20 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>0</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.20 ft	Fill height:	N/A	Limit depth:	N/A

### Check for strength loss plots (Idriss & Boulanger (2008))



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	4.20 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.20 ft	Fill height:	N/A	Limit depth:	N/A



**LIQUEFACTION ANALYSIS REPORT**

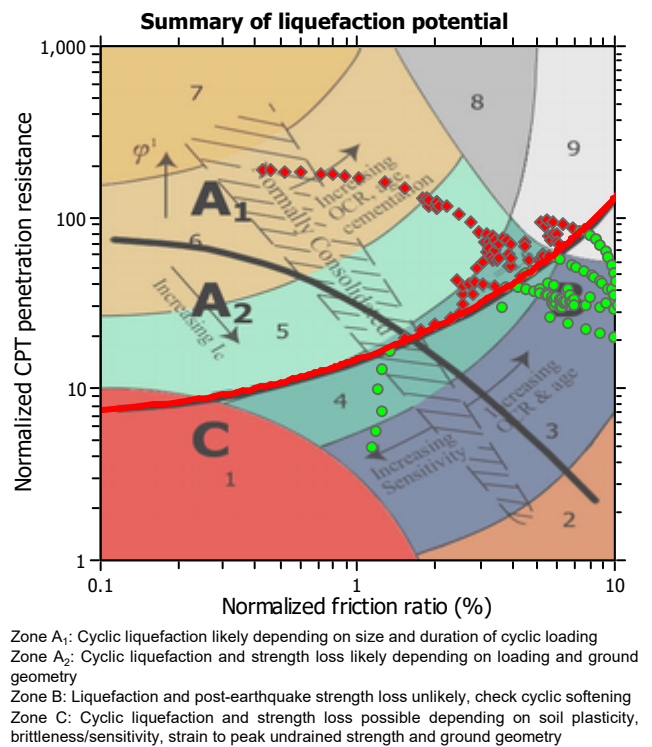
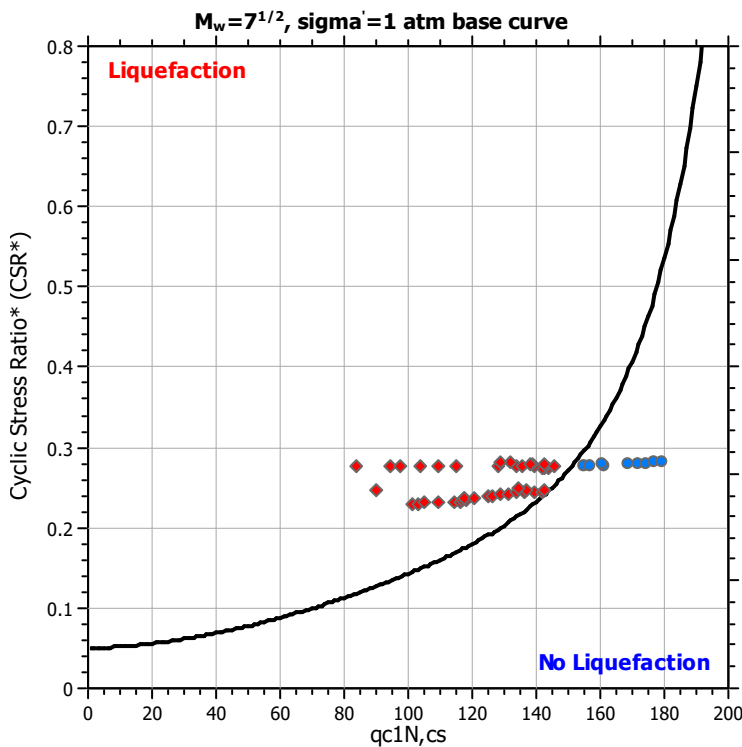
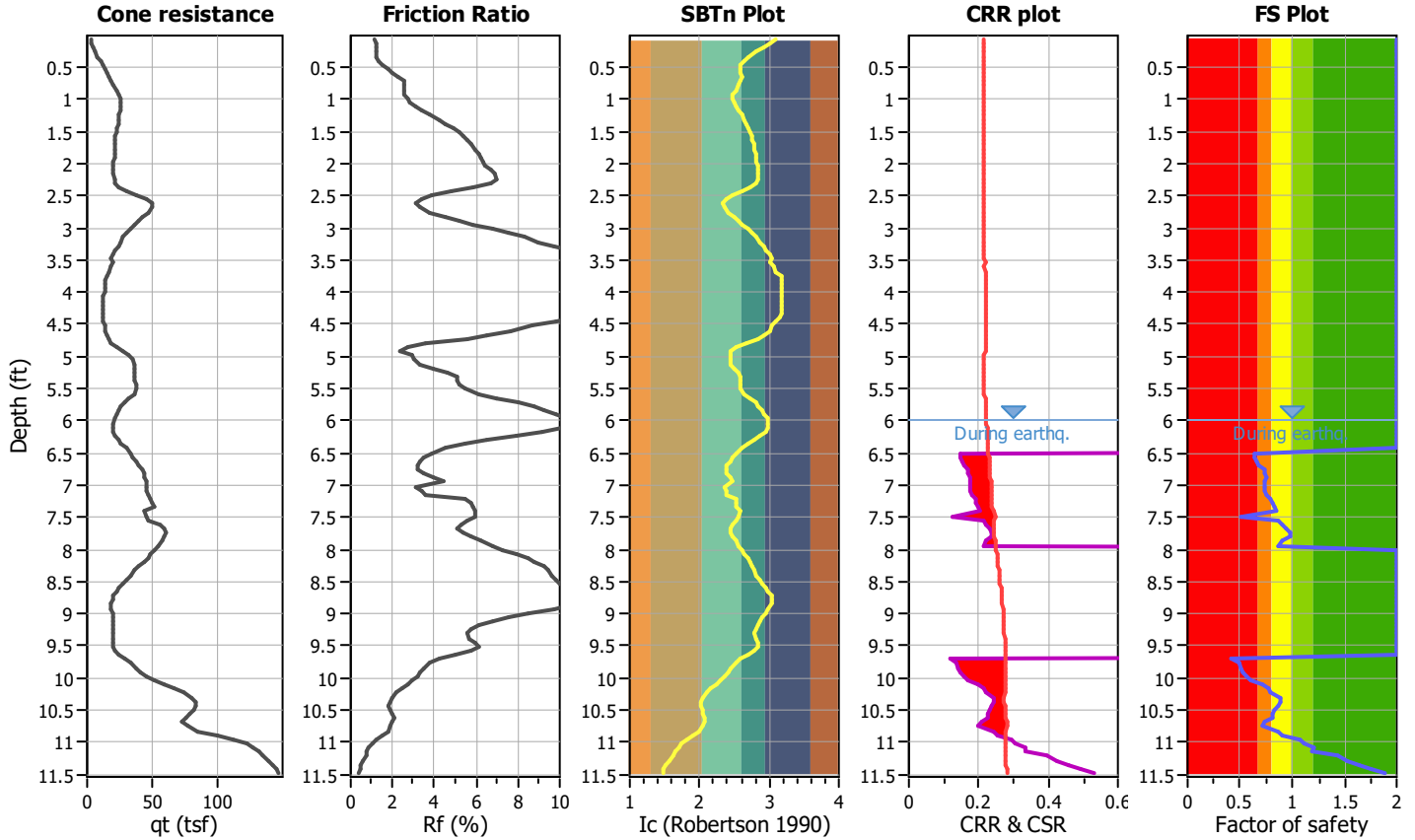
**Project title : CCR Ph 1**

**Location :**

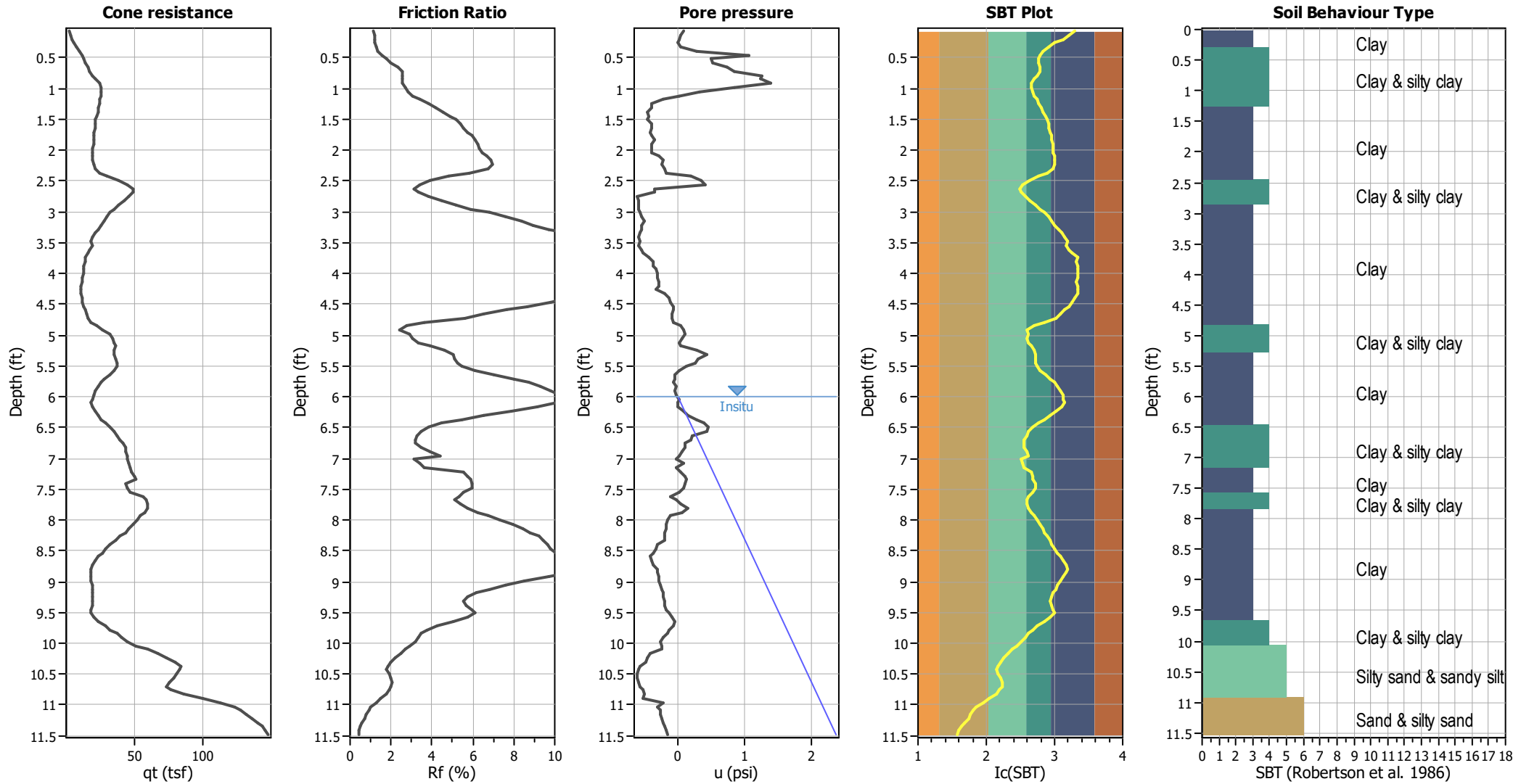
**CPT file : CPT-11B**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	6.00 ft	Use fill:	No	Clay like behavior	
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	6.00 ft	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.28	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.39	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes	MSF method:	Method



### CPT basic interpretation plots



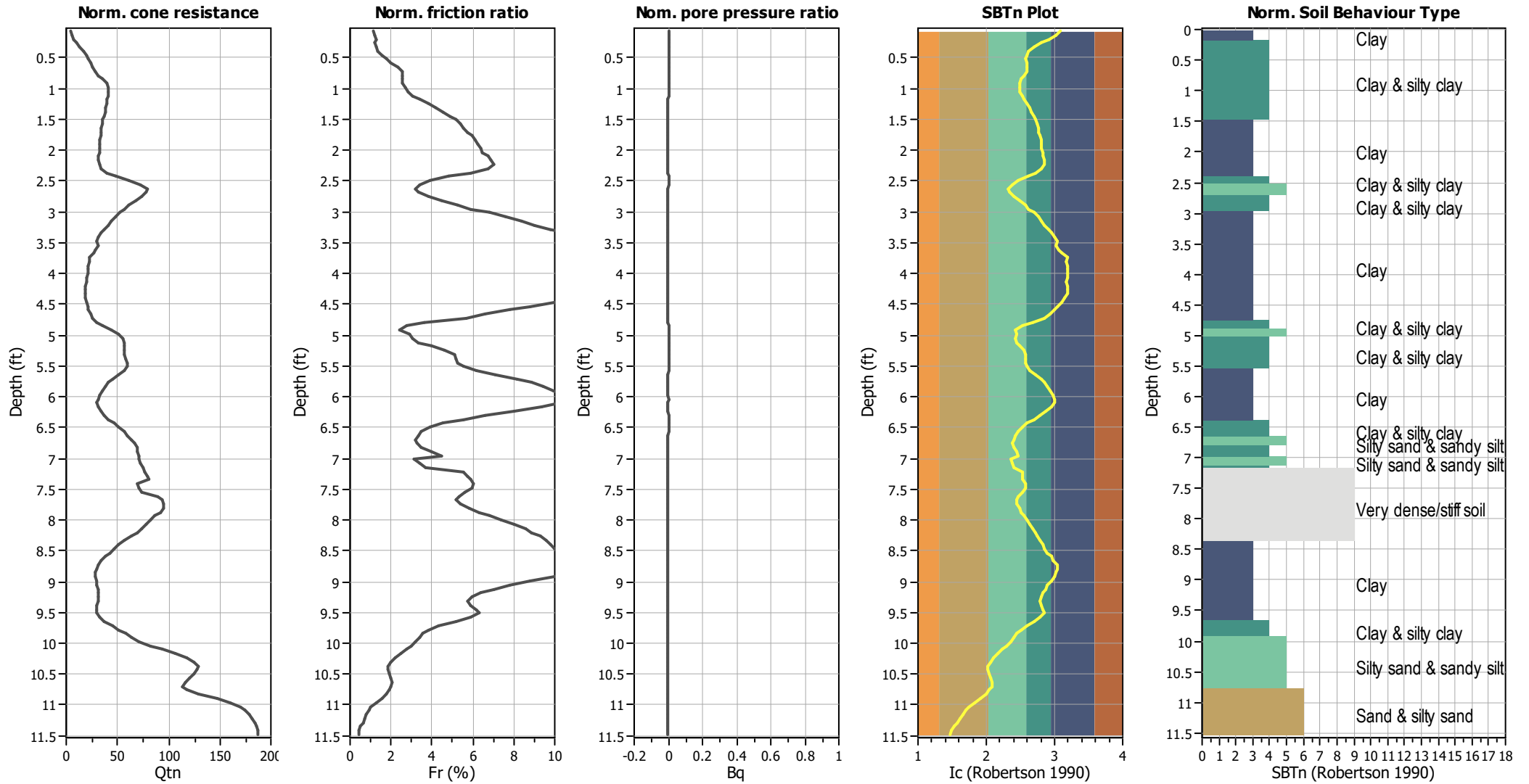
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	6.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	6.00 ft	Fill height:	N/A	Limit depth:	N/A

#### SBT legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

### CPT basic interpretation plots (normalized)



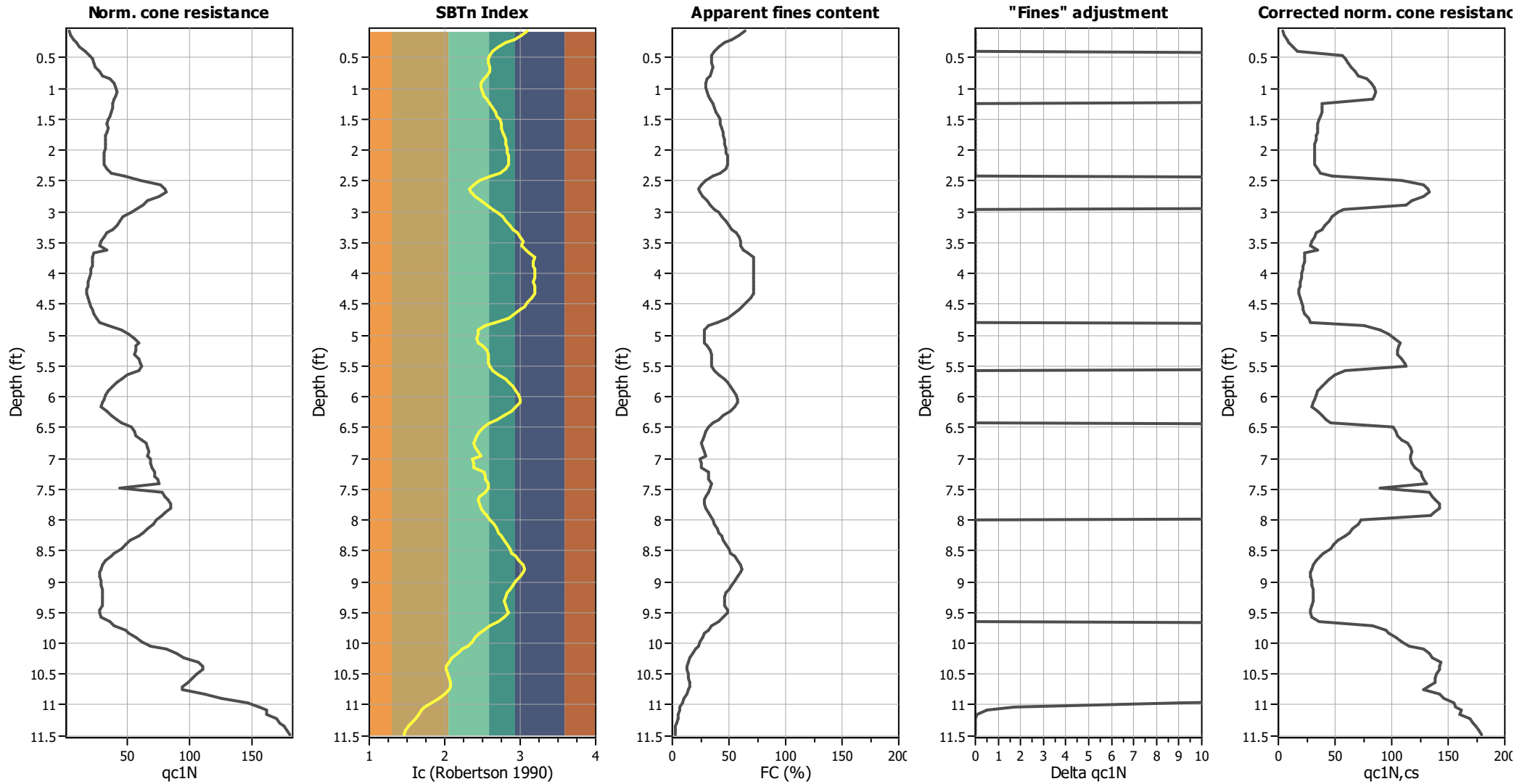
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	6.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	6.00 ft	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

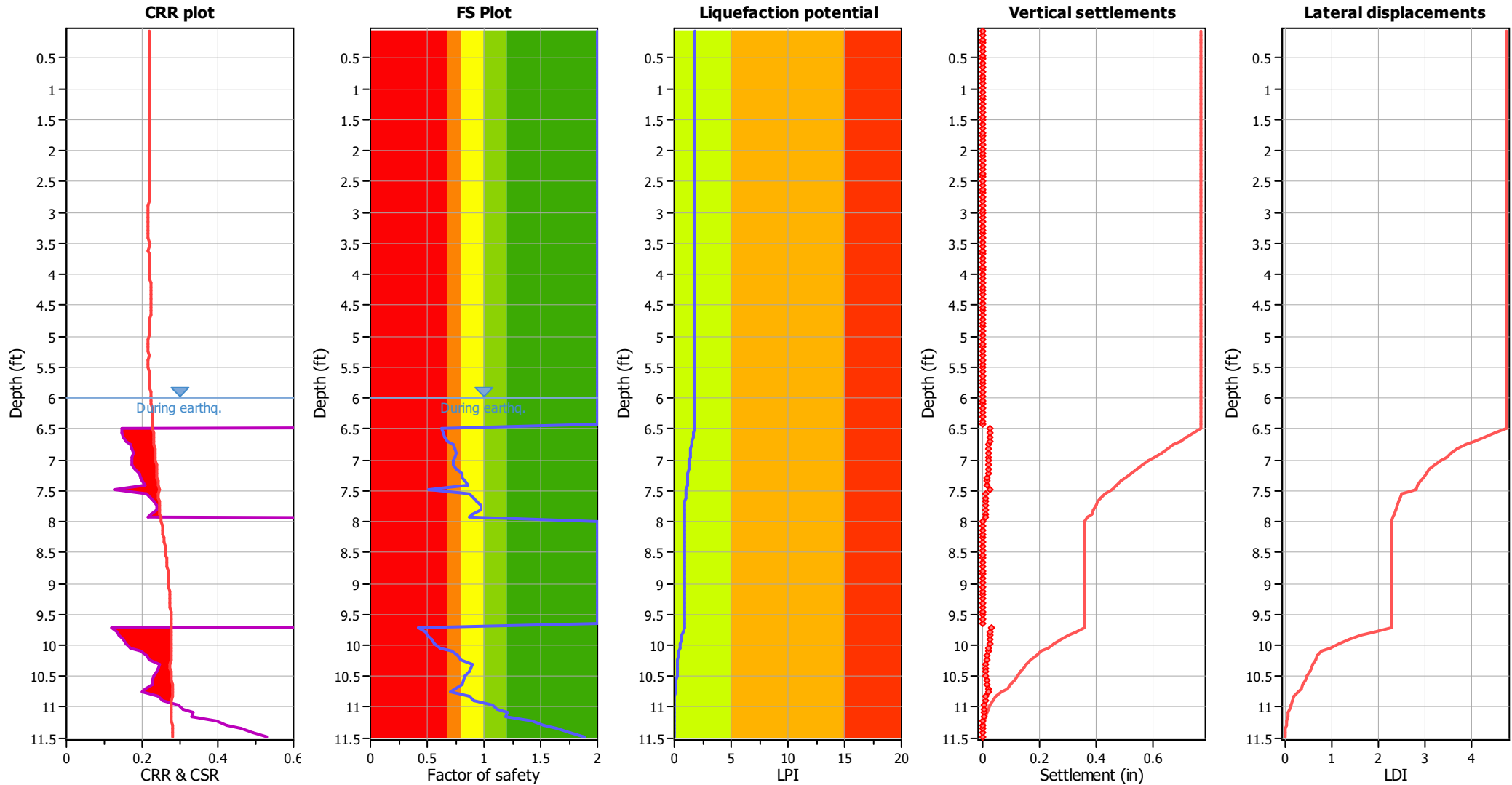
### Liquefaction analysis overall plots (intermediate results)



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	6.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	6.00 ft	Fill height:	N/A	Limit depth:	N/A

### Liquefaction analysis overall plots



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	6.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	6.00 ft	Fill height:	N/A	Limit depth:	N/A

**F.S. color scheme**

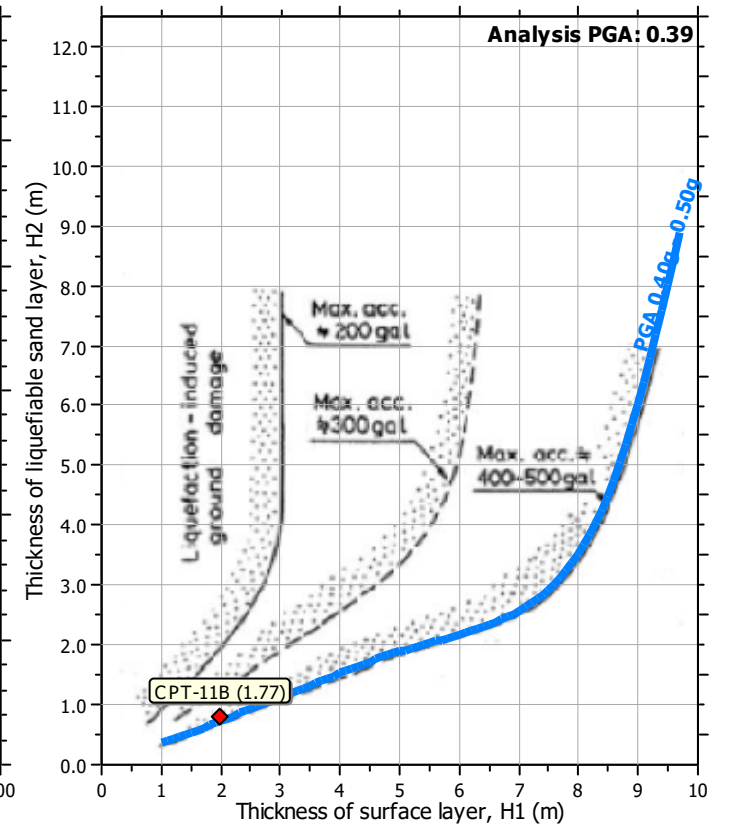
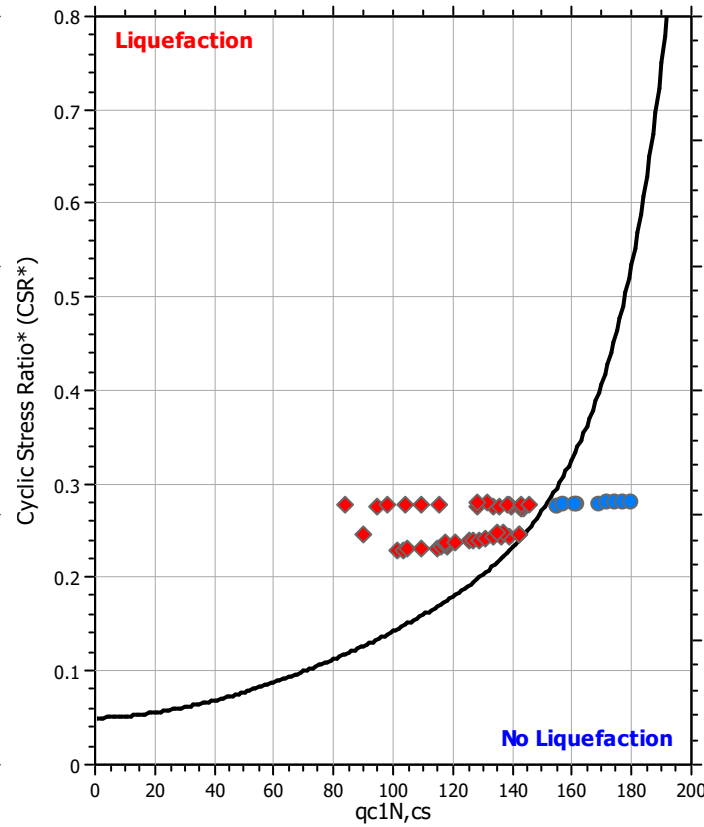
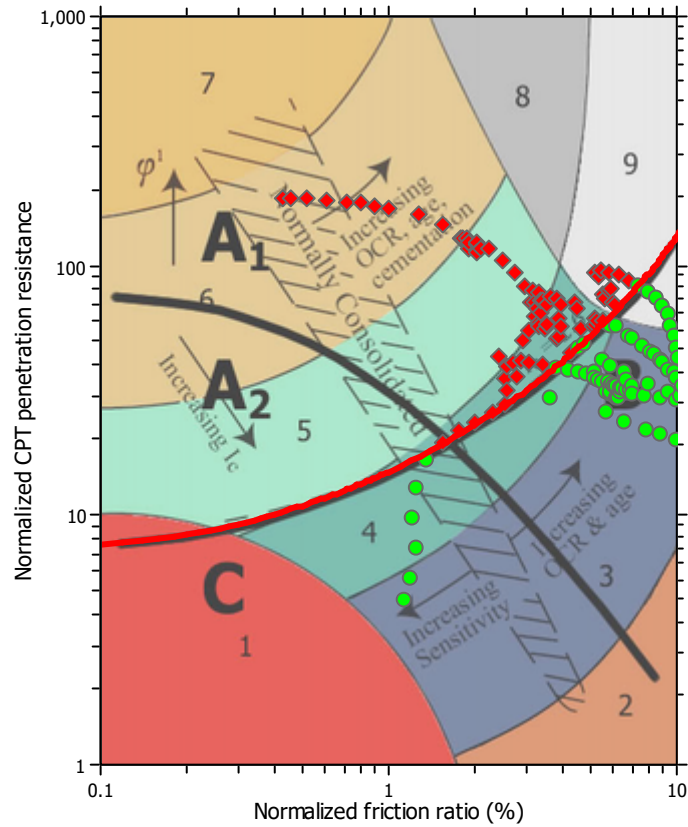
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk



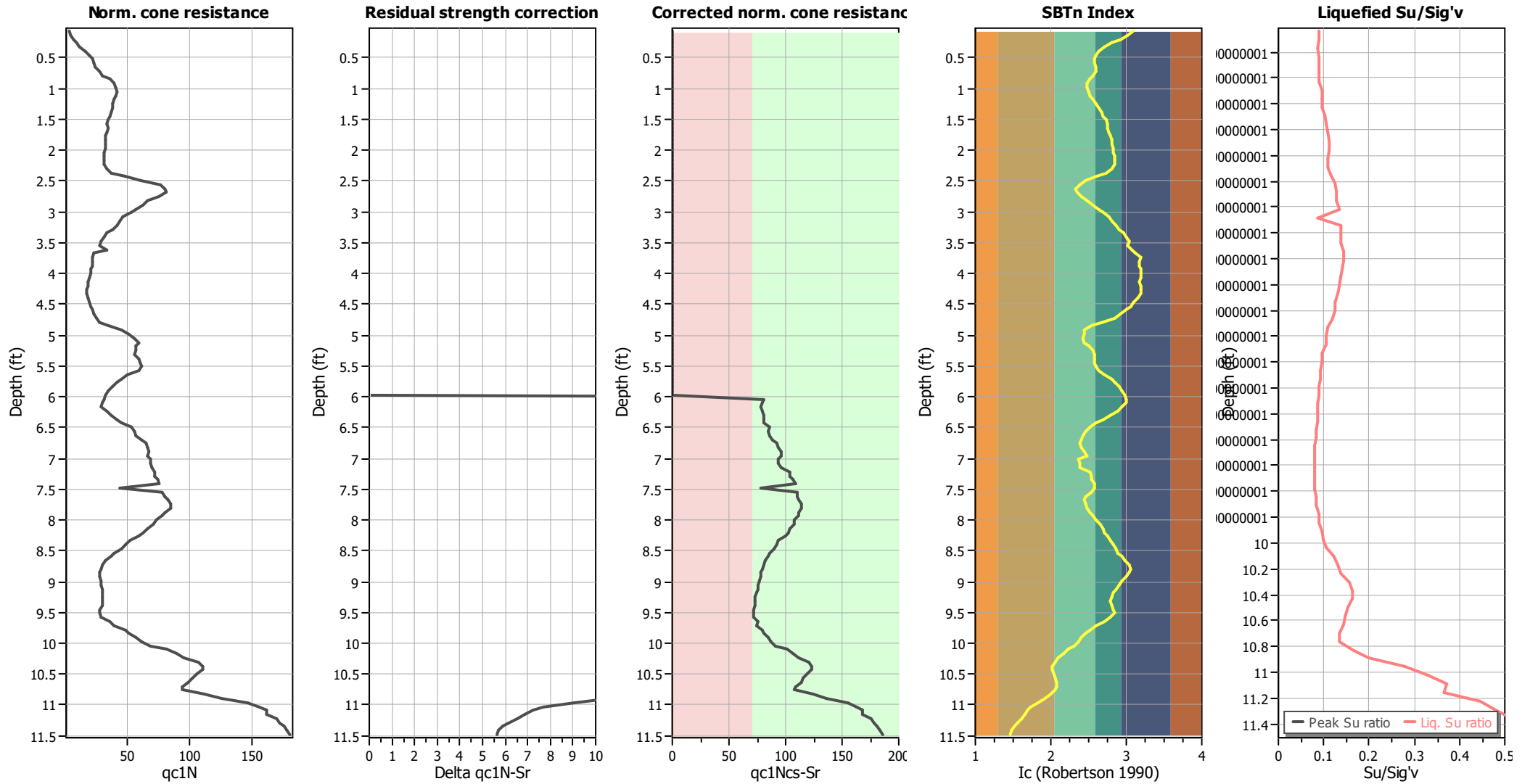
### Liquefaction analysis summary plots



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	6.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on I <sub>c</sub> value	I <sub>c</sub> cut-off value:	2.60	K <sub>0</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	6.00 ft	Fill height:	N/A	Limit depth:	N/A

### Check for strength loss plots (Idriss & Boulanger (2008))



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	6.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	6.00 ft	Fill height:	N/A	Limit depth:	N/A

**LIQUEFACTION ANALYSIS REPORT**

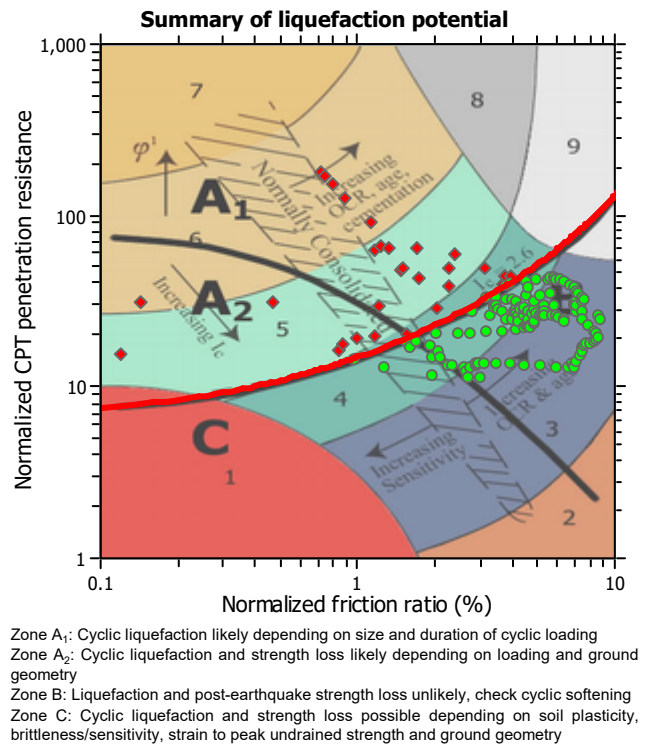
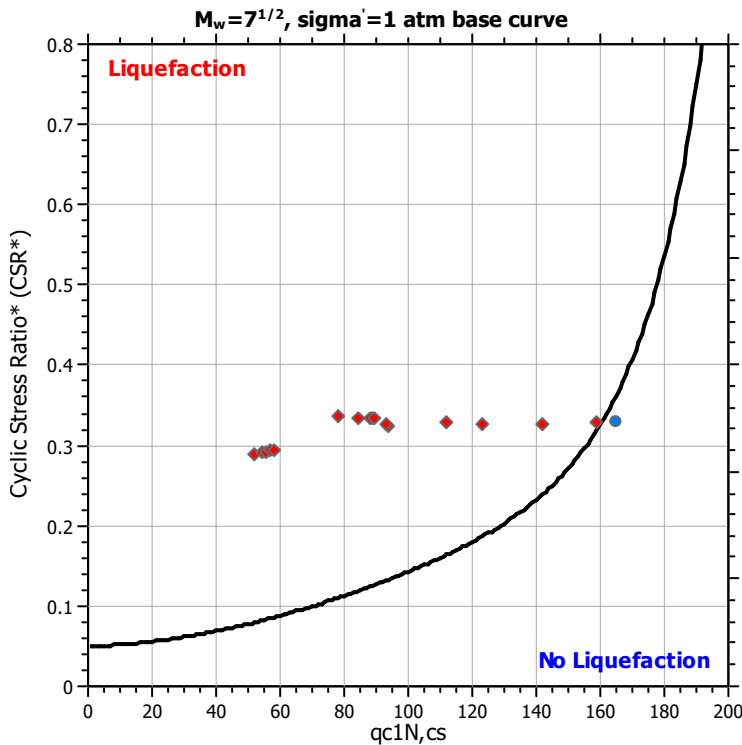
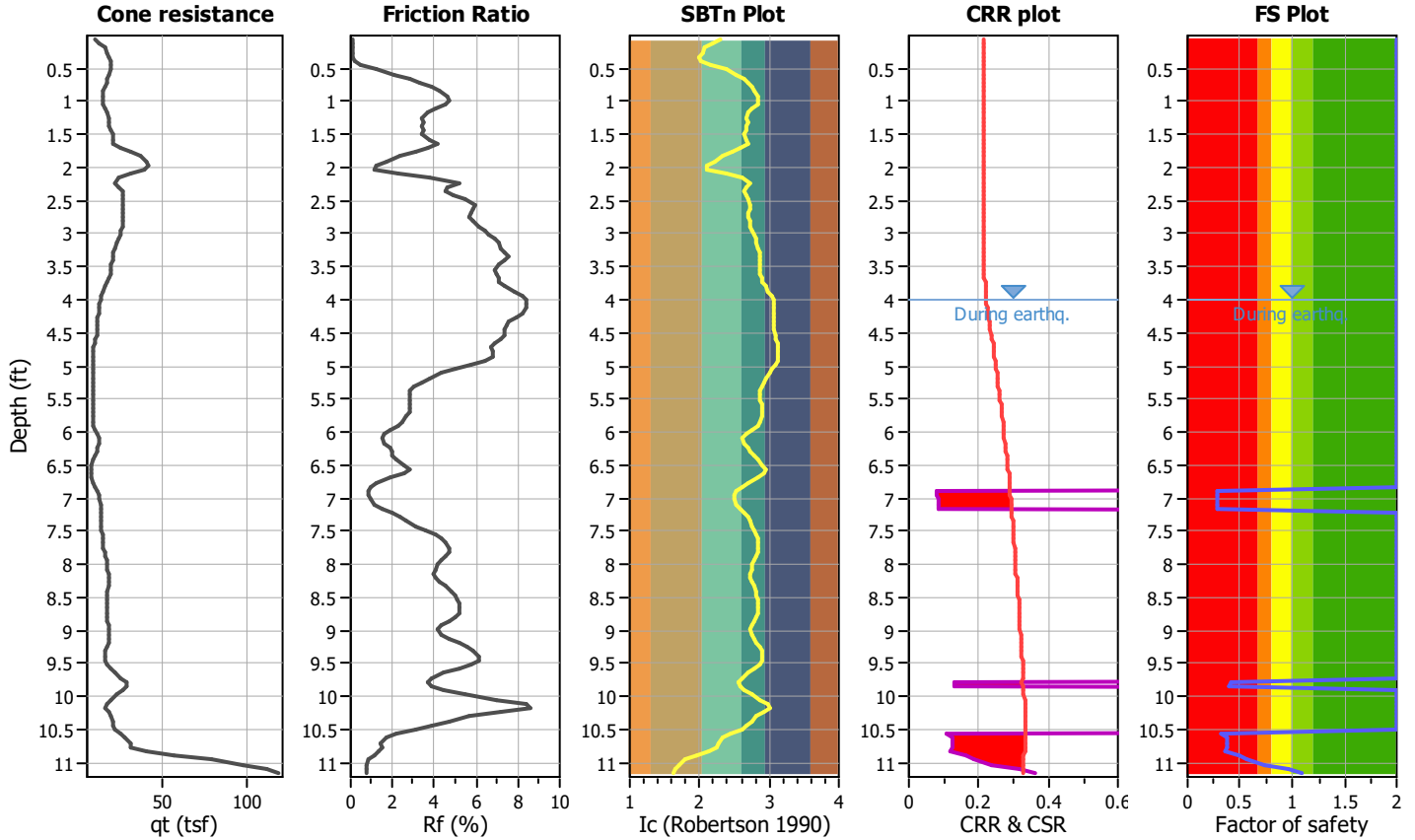
**Project title : CCR Ph 1**

**Location :**

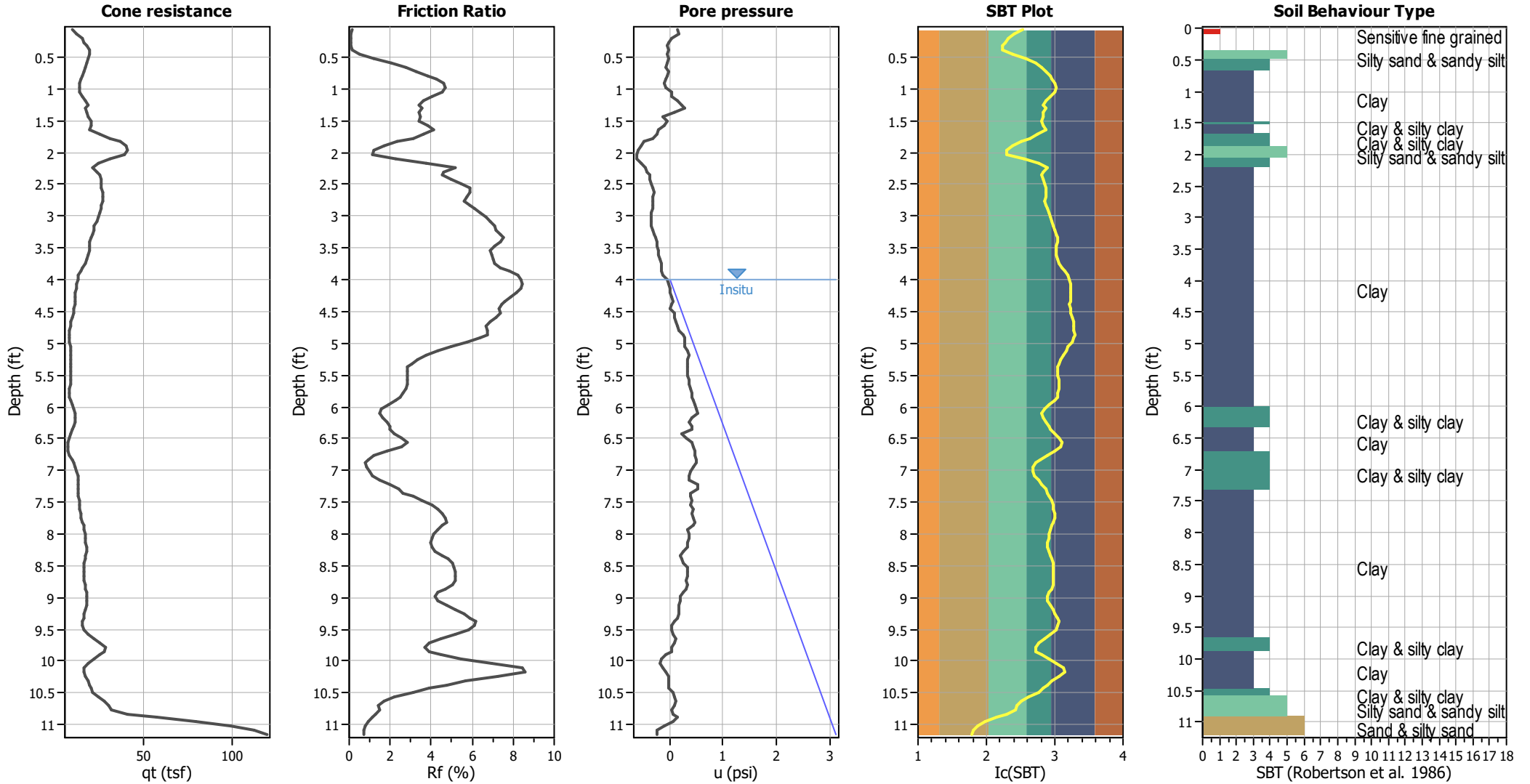
**CPT file : CPT-12B**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	4.00 ft	Use fill:	No	Clay like behavior	
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	4.00 ft	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.28	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.39	Unit weight calculation:	Based on SBT	$K_f$ applied:	Yes	MSF method:	Method



### CPT basic interpretation plots



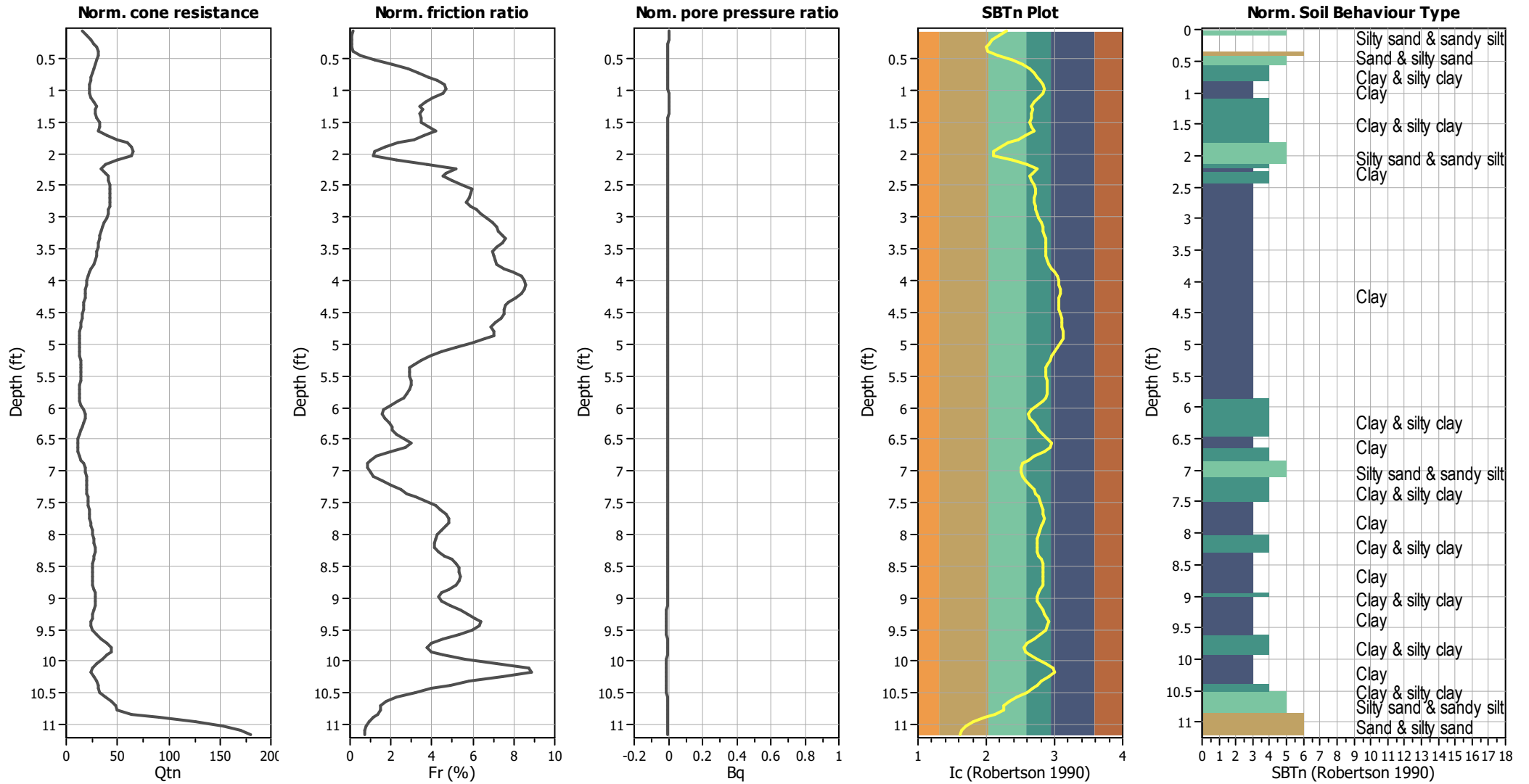
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	4.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 ft	Fill height:	N/A	Limit depth:	N/A

#### SBT legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

### CPT basic interpretation plots (normalized)



#### Input parameters and analysis data

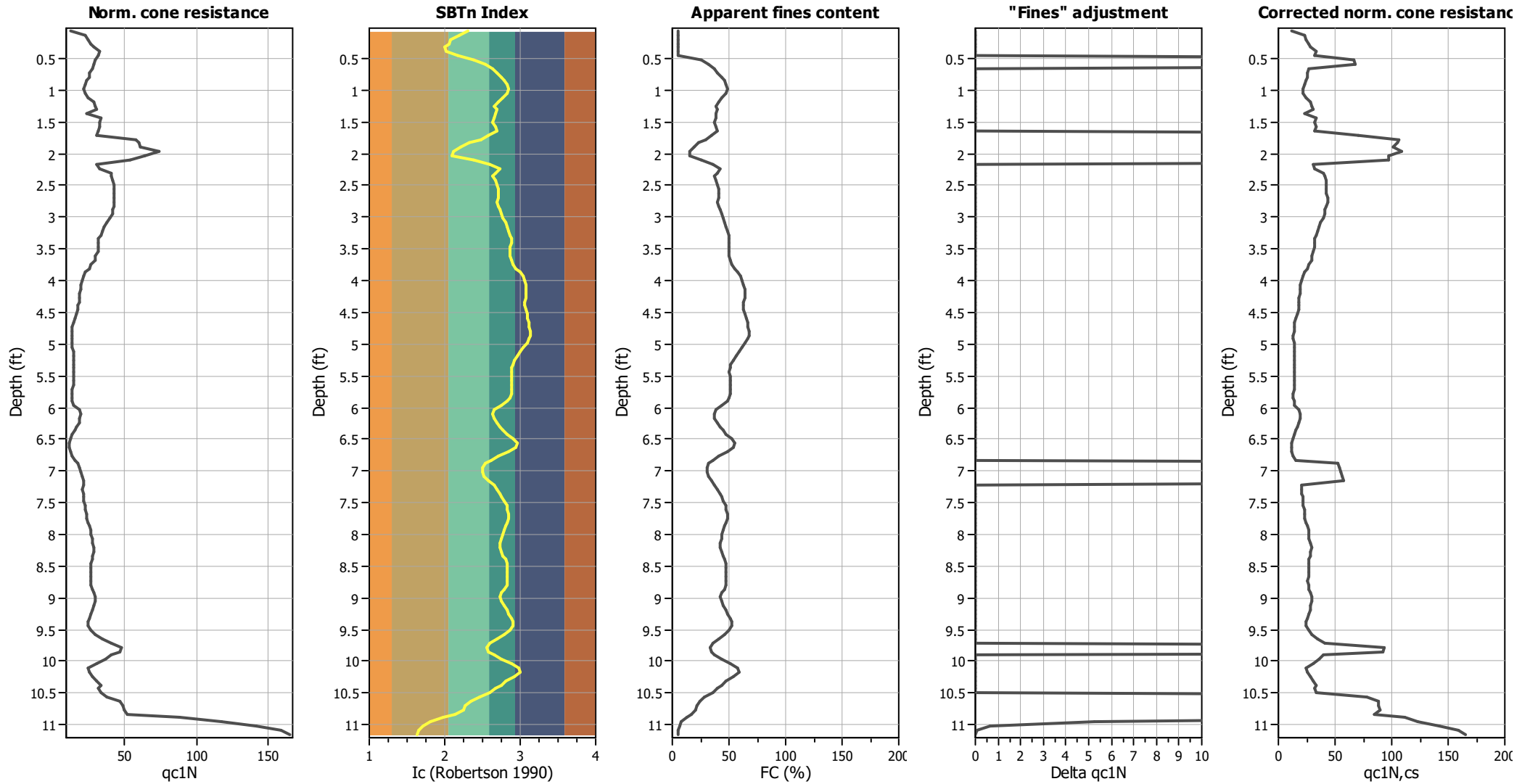
Analysis method:	I&B (2008)	Depth to GWT (erthq.):	4.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 ft	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained



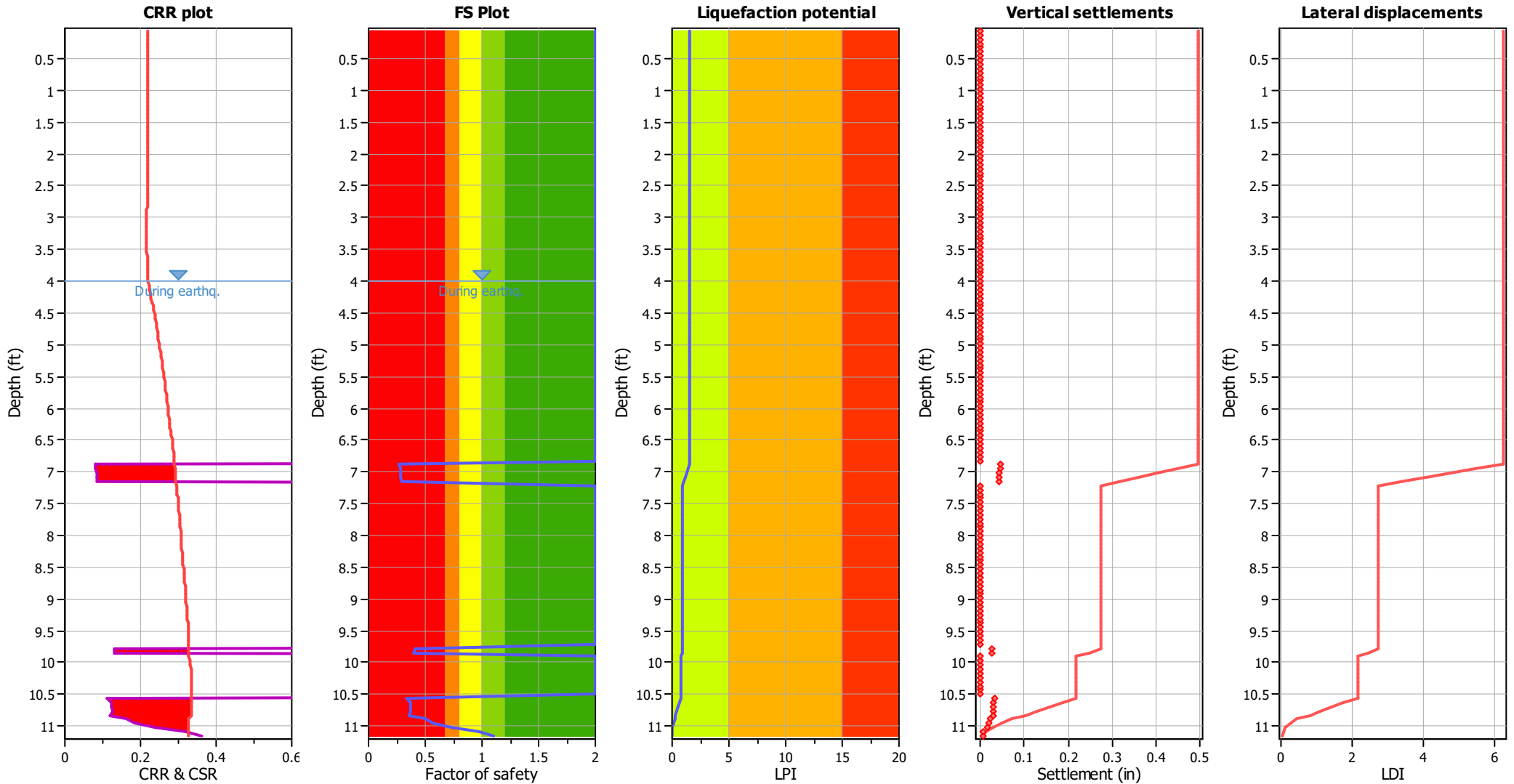
### Liquefaction analysis overall plots (intermediate results)



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	4.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 ft	Fill height:	N/A	Limit depth:	N/A

### Liquefaction analysis overall plots



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	4.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 ft	Fill height:	N/A	Limit depth:	N/A

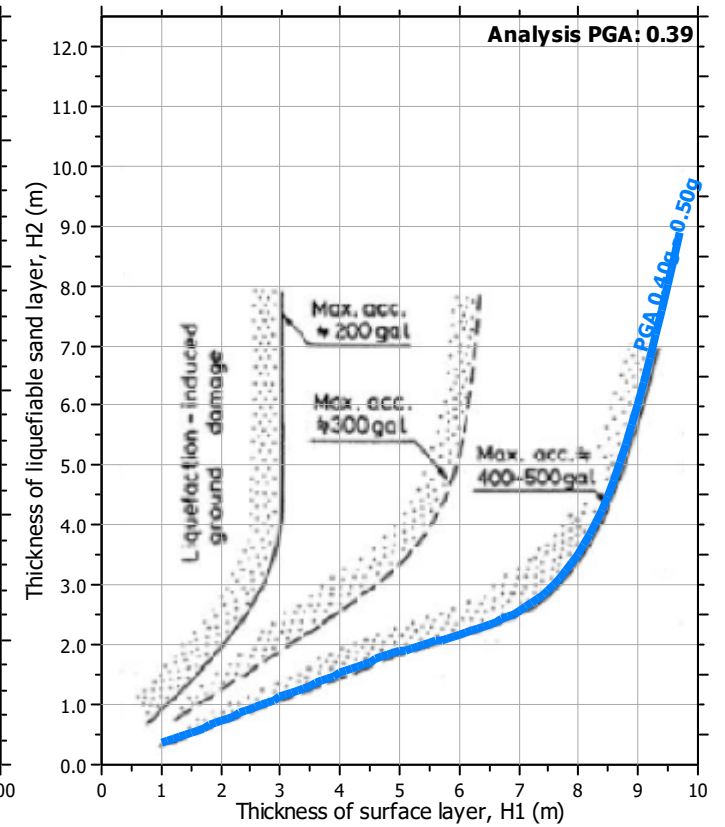
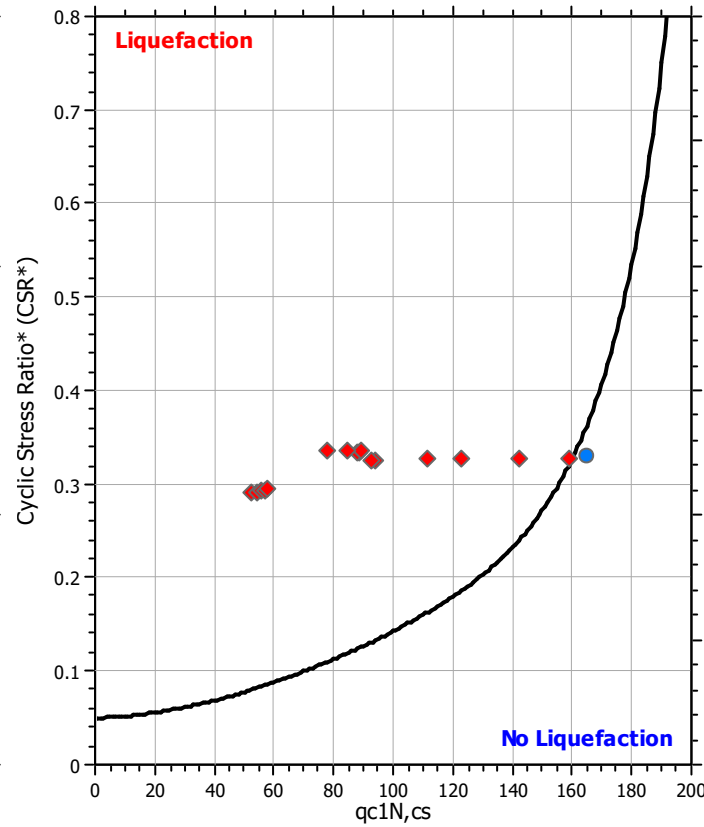
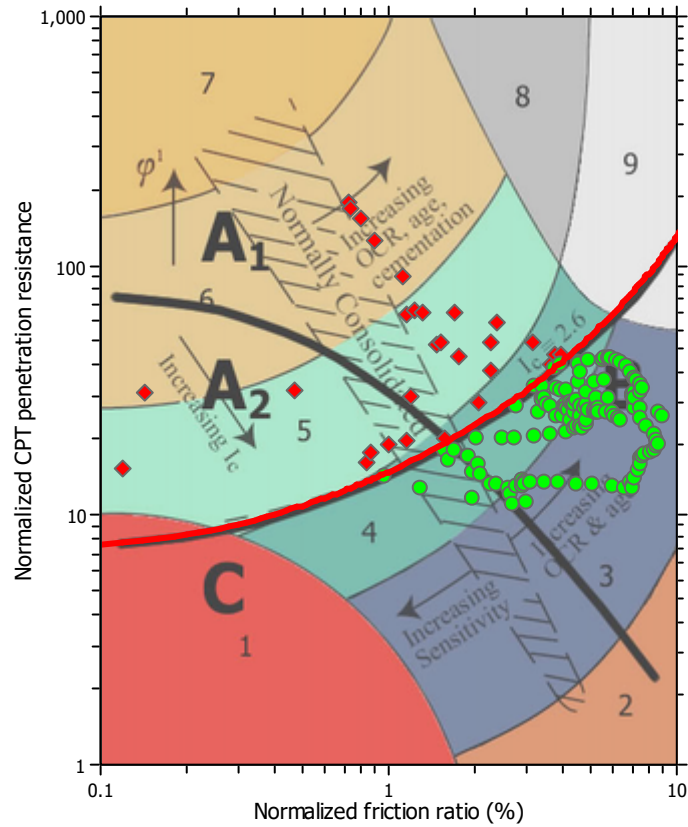
**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

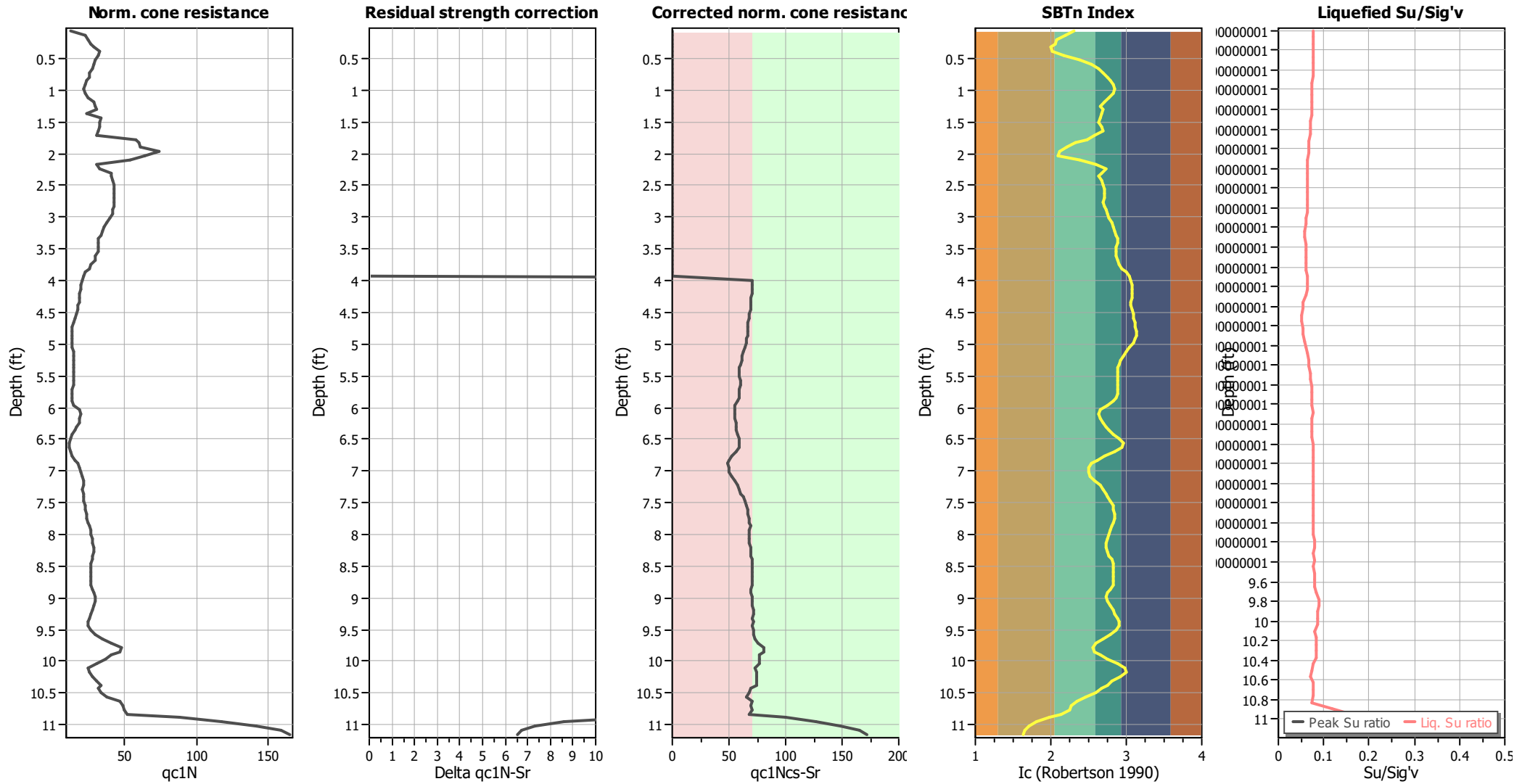
### Liquefaction analysis summary plots



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	4.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>0</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 ft	Fill height:	N/A	Limit depth:	N/A

### Check for strength loss plots (Idriss & Boulanger (2008))



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	4.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	4.00 ft	Fill height:	N/A	Limit depth:	N/A

**LIQUEFACTION ANALYSIS REPORT**

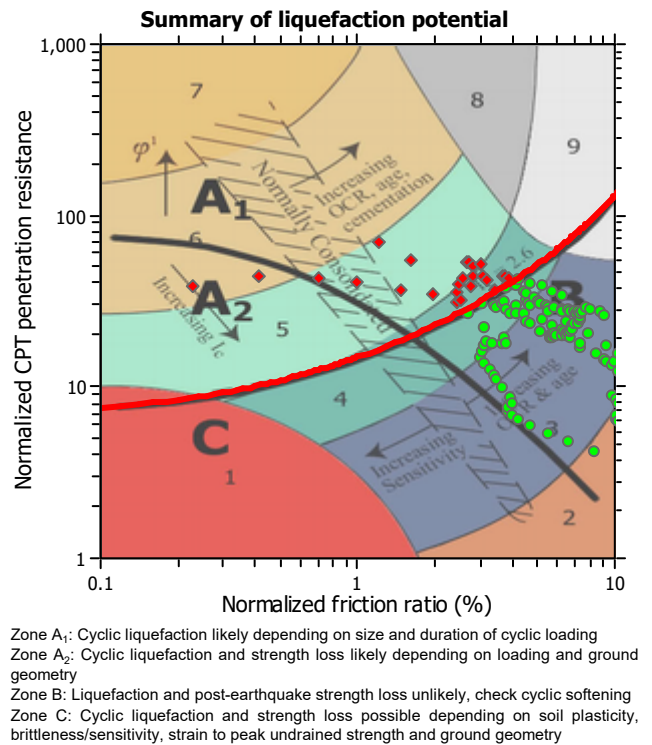
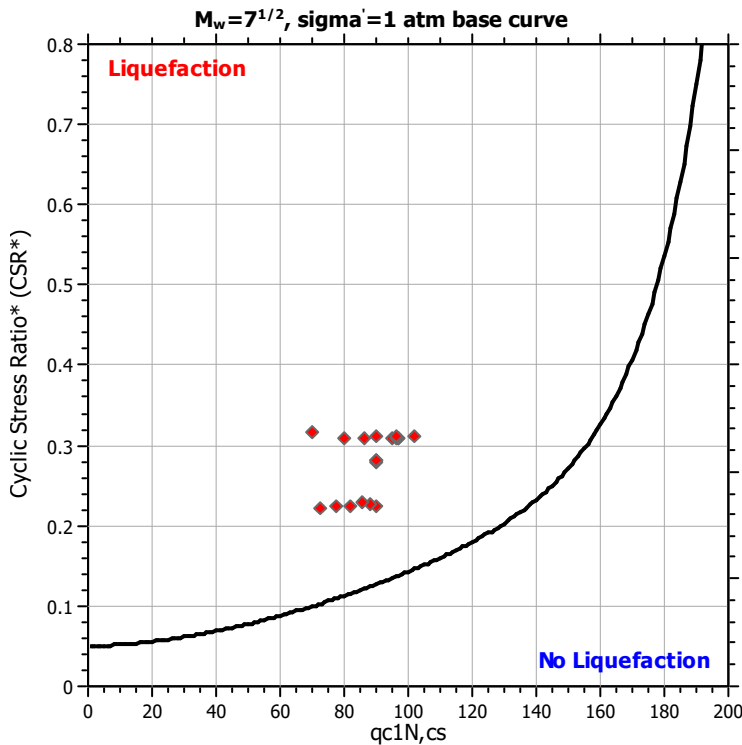
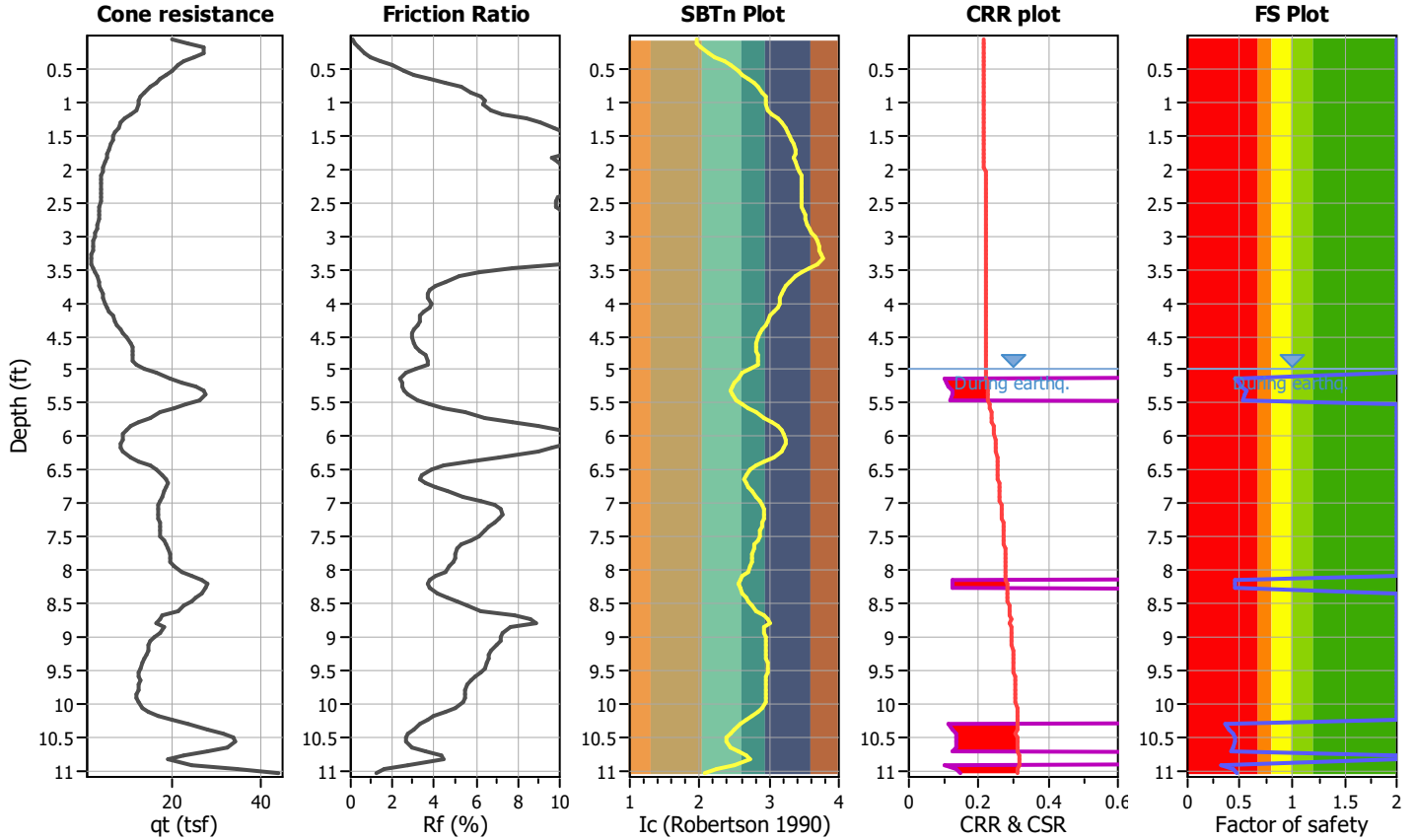
**Project title : CCR Ph 1**

**Location :**

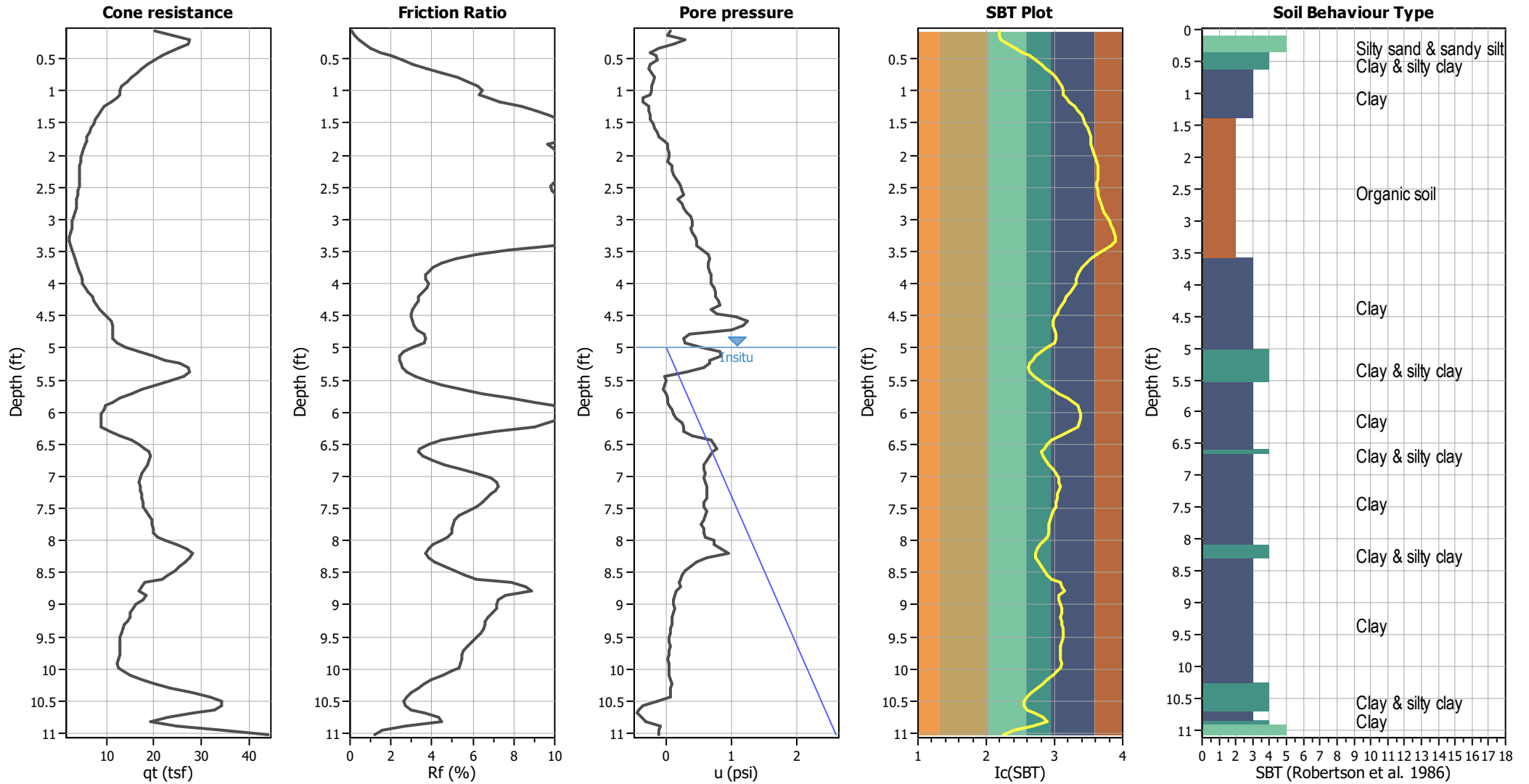
**CPT file : CPT-13B**

**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	5.00 ft	Use fill:	No	Clay like behavior	
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	5.00 ft	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	No
Earthquake magnitude $M_w$ :	7.28	Ic cut-off value:	2.60	Trans. detect. applied:	No	Limit depth:	N/A
Peak ground acceleration:	0.39	Unit weight calculation:	Based on SBT	$K_f$ applied:	Yes	MSF method:	Method



### CPT basic interpretation plots



#### Input parameters and analysis data

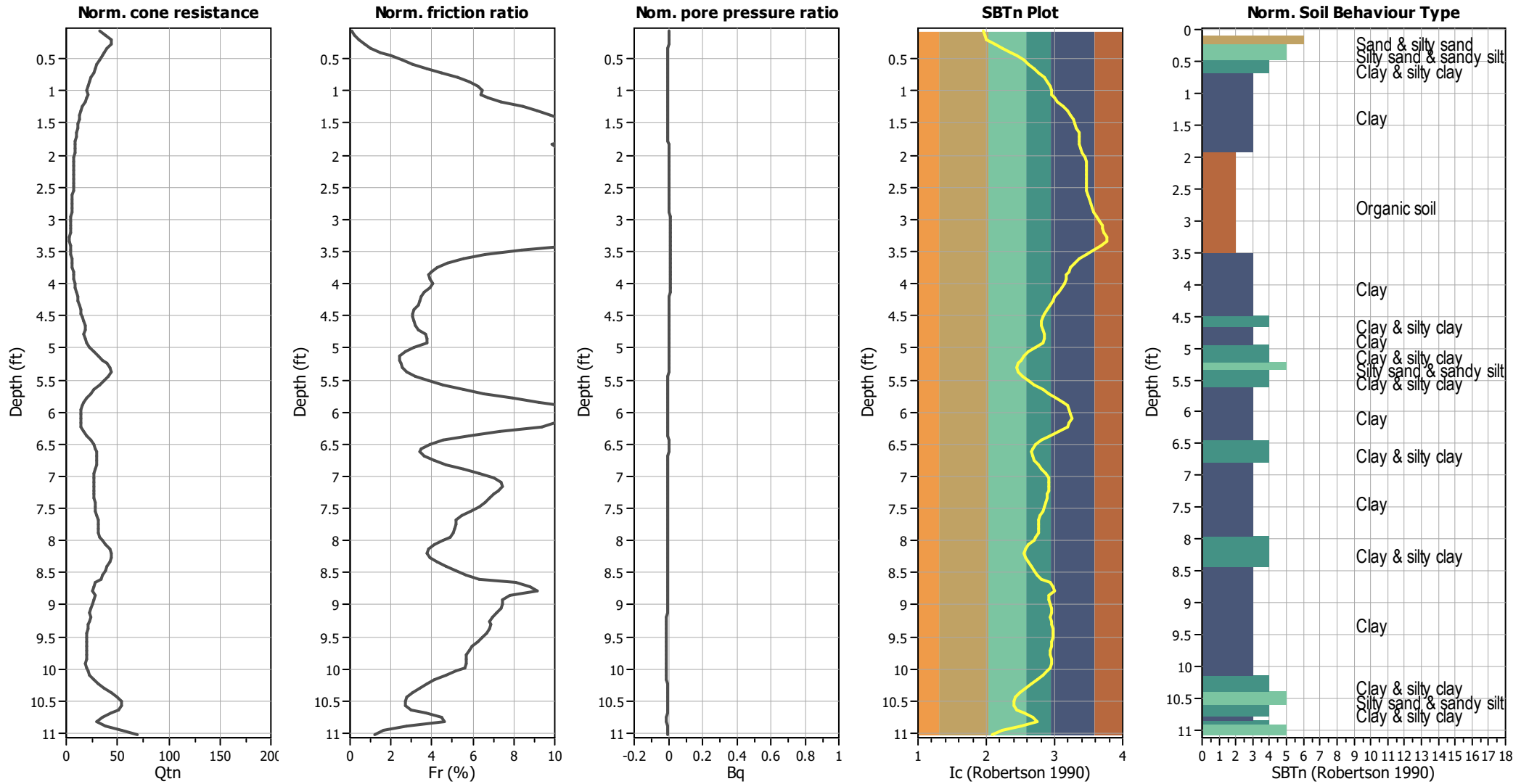
Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>0</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

#### SBT legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained



### CPT basic interpretation plots (normalized)



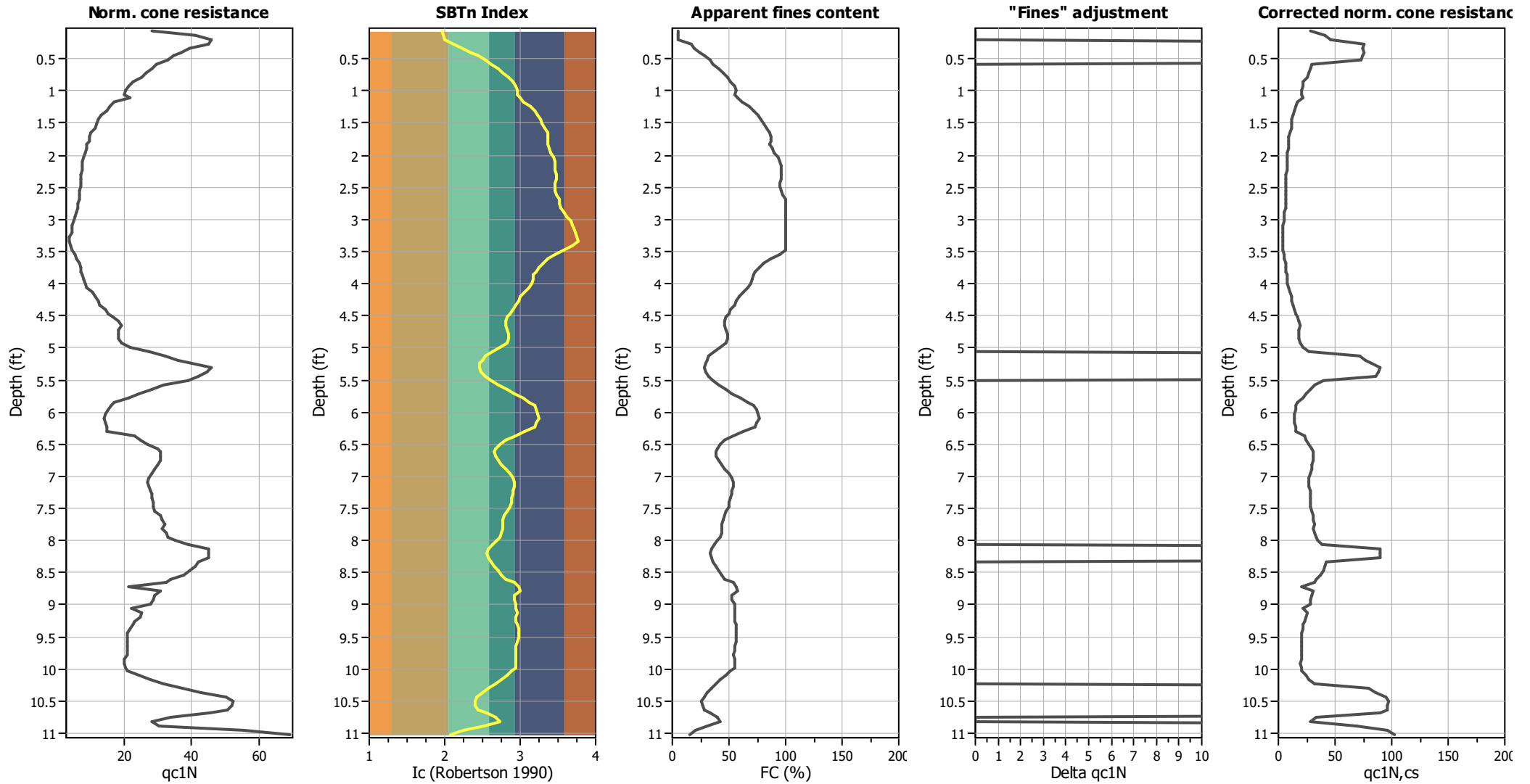
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>0</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

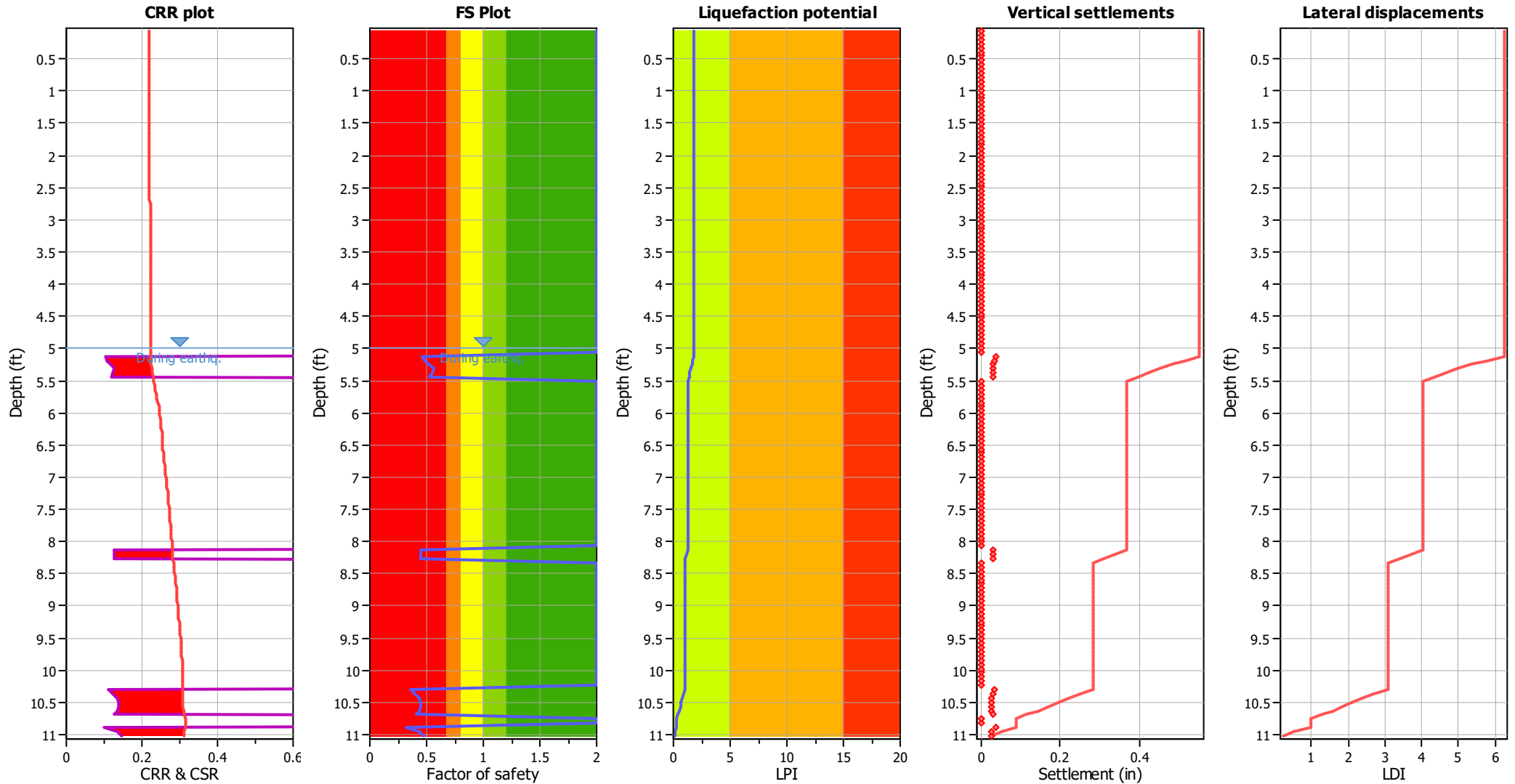
### Liquefaction analysis overall plots (intermediate results)



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

### Liquefaction analysis overall plots



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_{\sigma}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

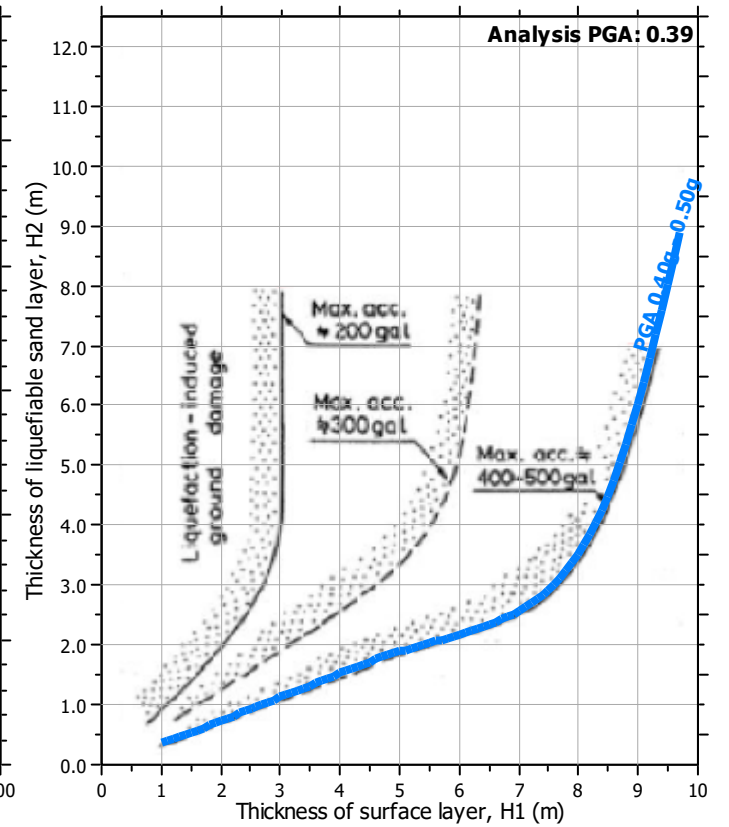
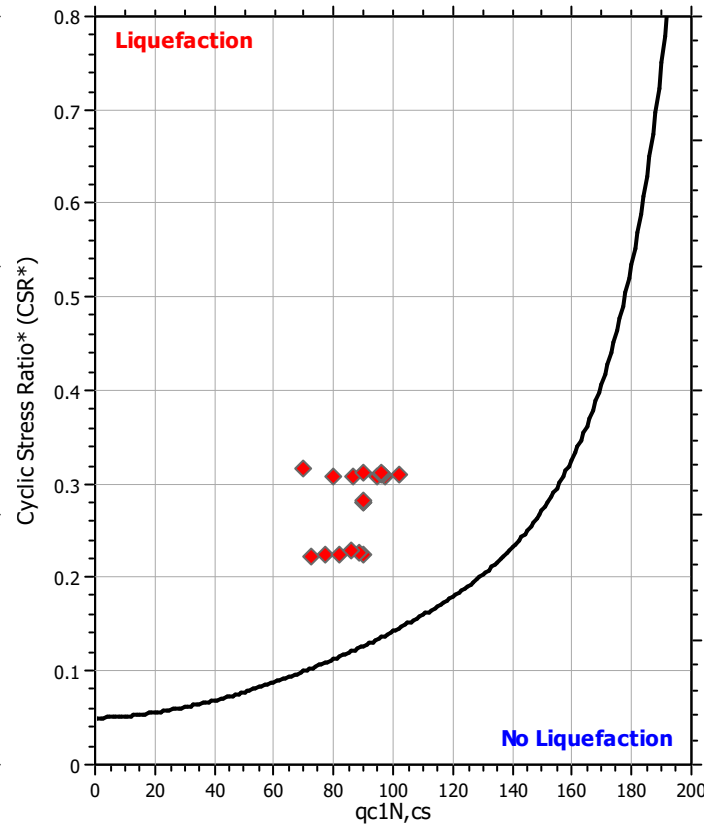
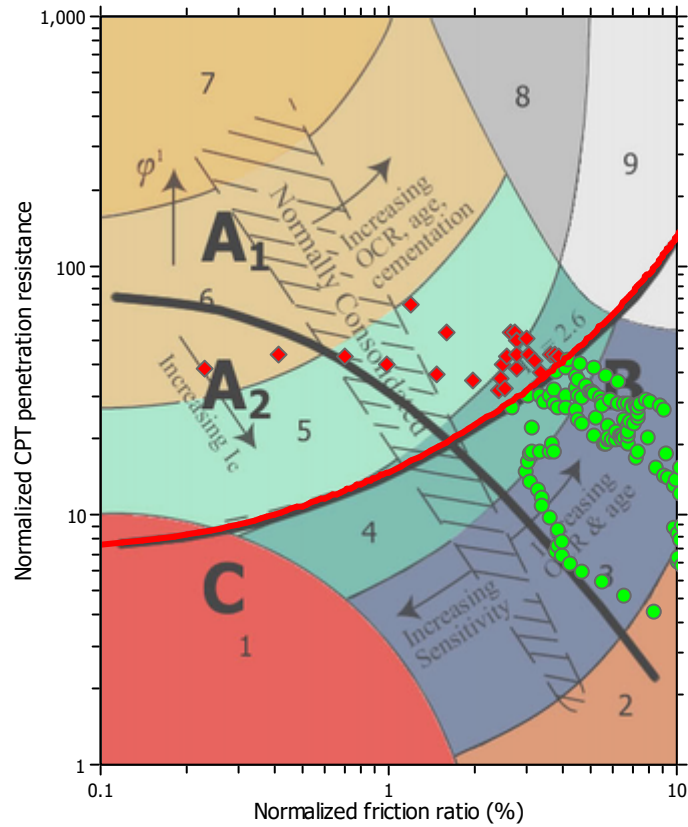
**F.S. color scheme**

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

**LPI color scheme**

- Very high risk
- High risk
- Low risk

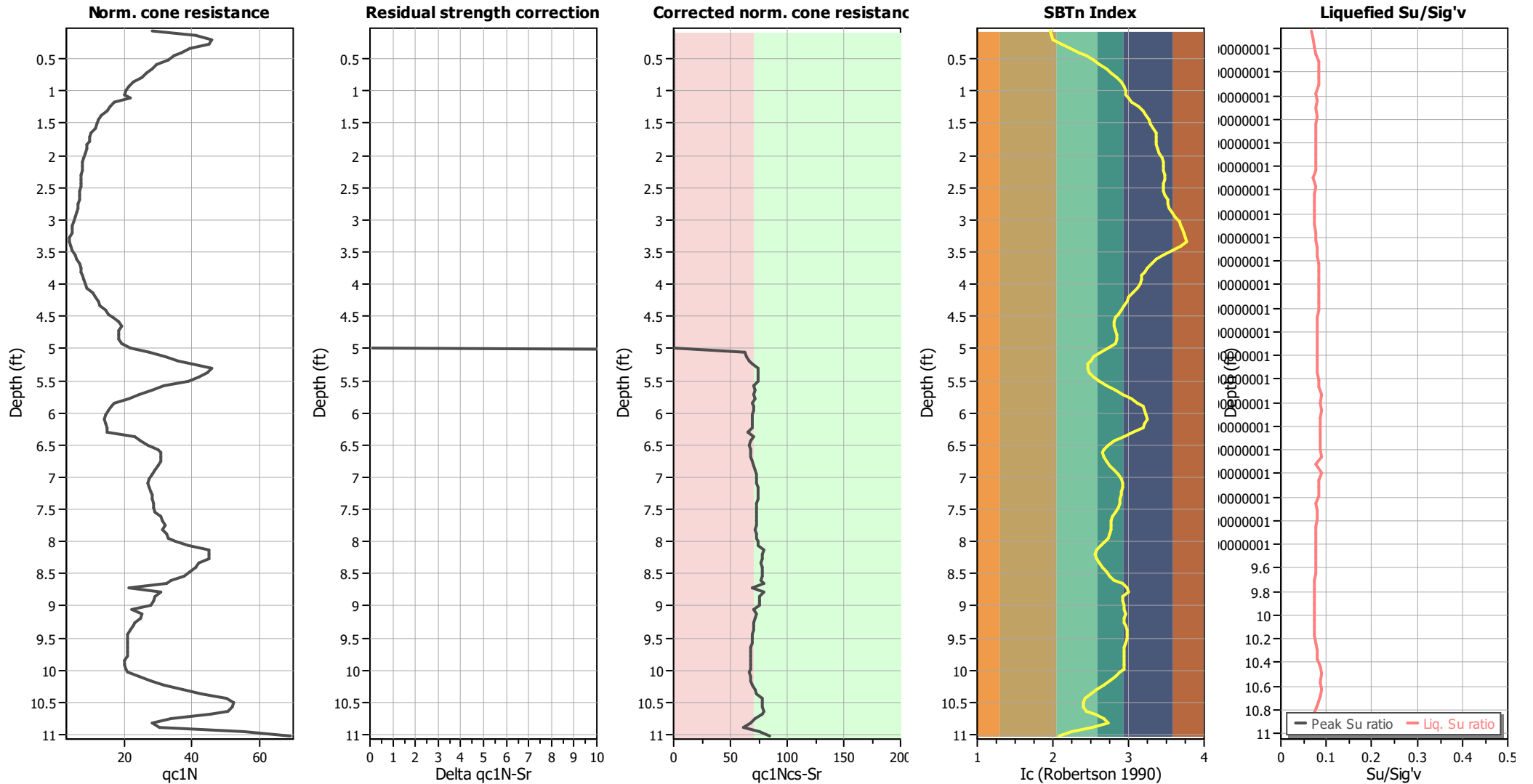
### Liquefaction analysis summary plots



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on $I_c$ value	$I_c$ cut-off value:	2.60	$K_{\phi}$ applied:	Yes
Earthquake magnitude $M_w$ :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

### Check for strength loss plots (Idriss & Boulanger (2008))



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

**LIQUEFACTION ANALYSIS REPORT**

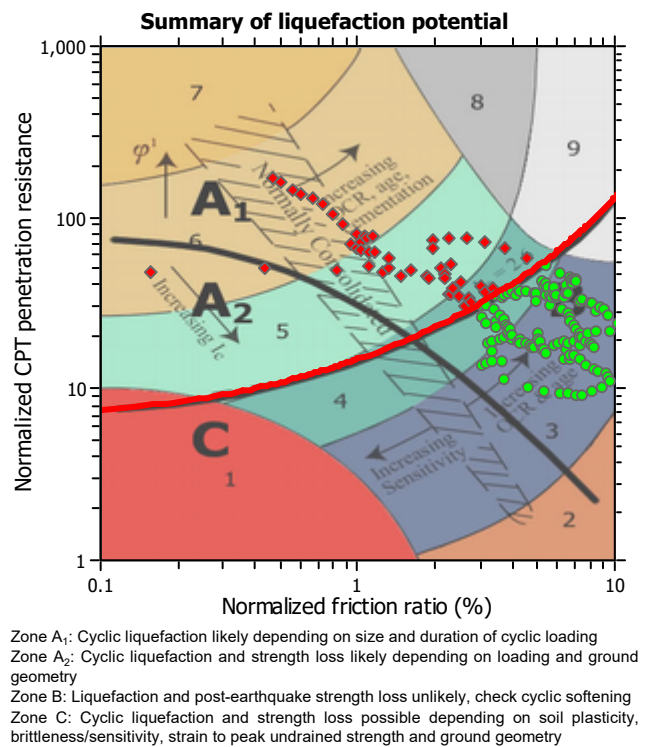
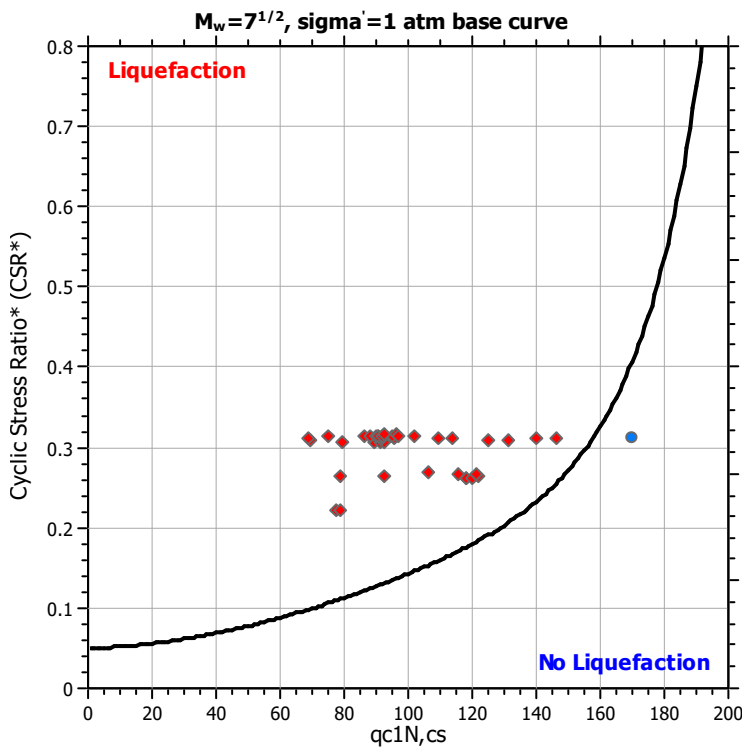
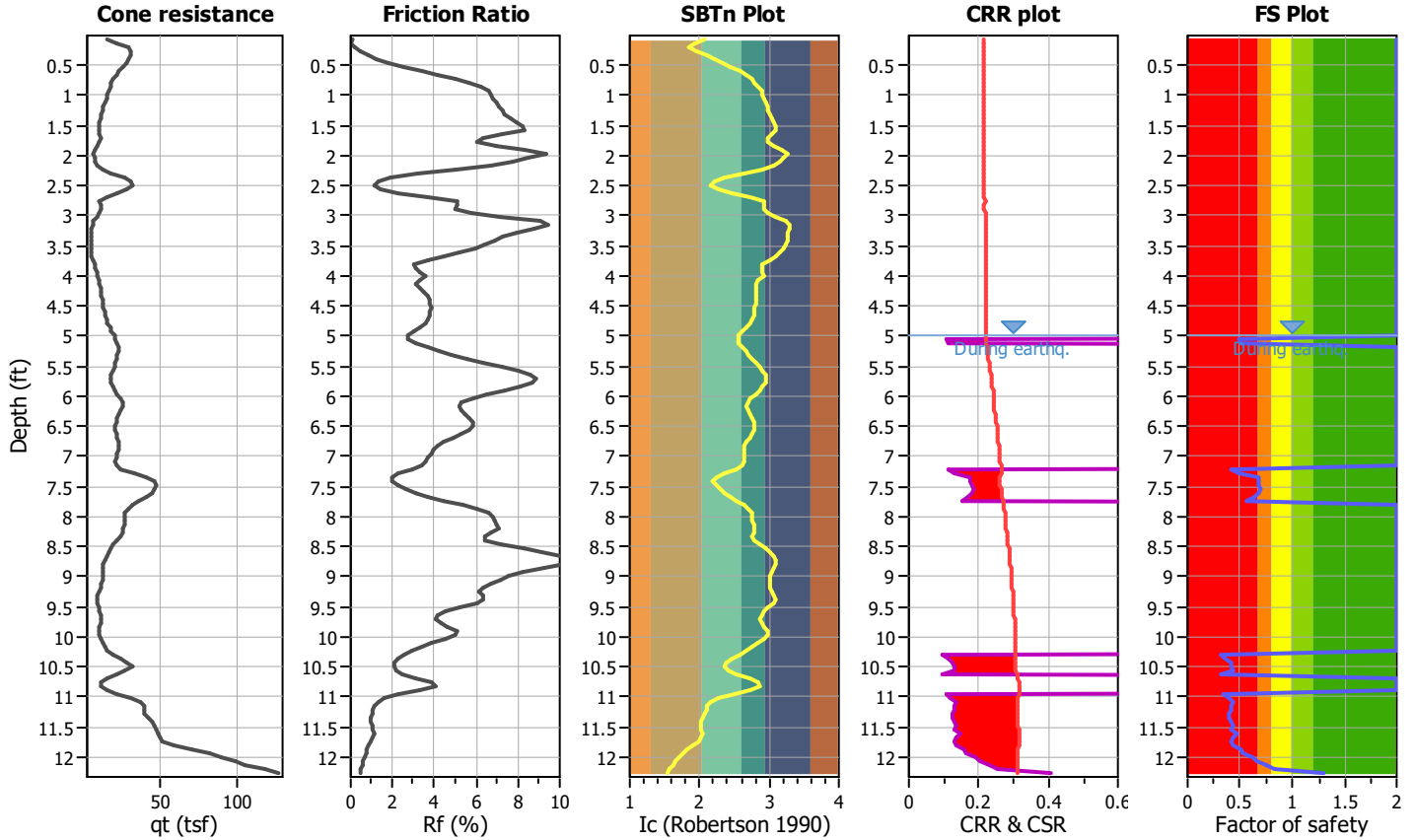
**Project title : CCR Ph 1**

**Location :**

**CPT file : CPT-14B**

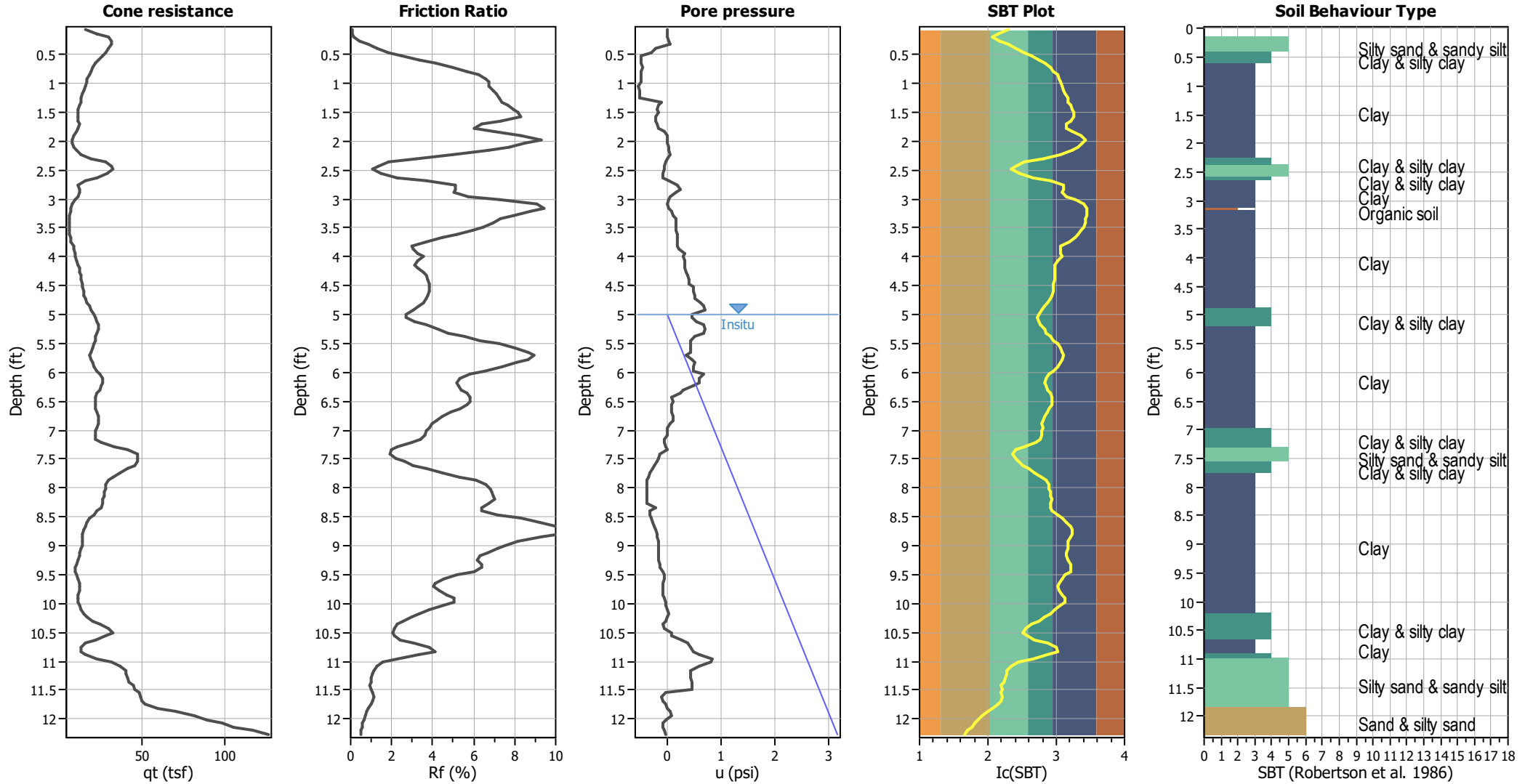
**Input parameters and analysis data**

Analysis method:	I&B (2008)	G.W.T. (in-situ):	5.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	5.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude $M_w$ :	7.28	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method
Peak ground acceleration:	0.39	Unit weight calculation:	Based on SBT	$K_\sigma$ applied:	Yes		





### CPT basic interpretation plots



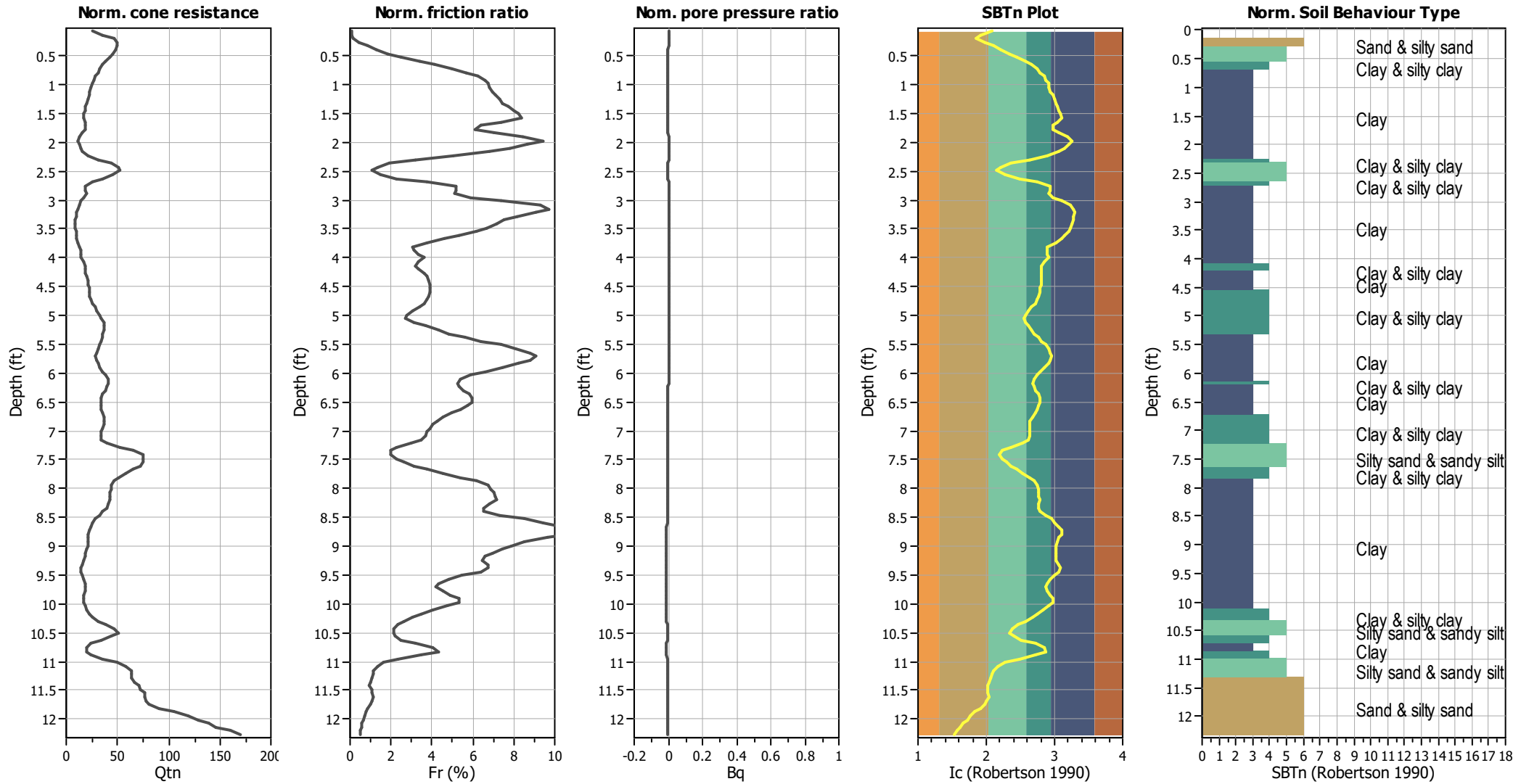
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

#### SBT legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

### CPT basic interpretation plots (normalized)



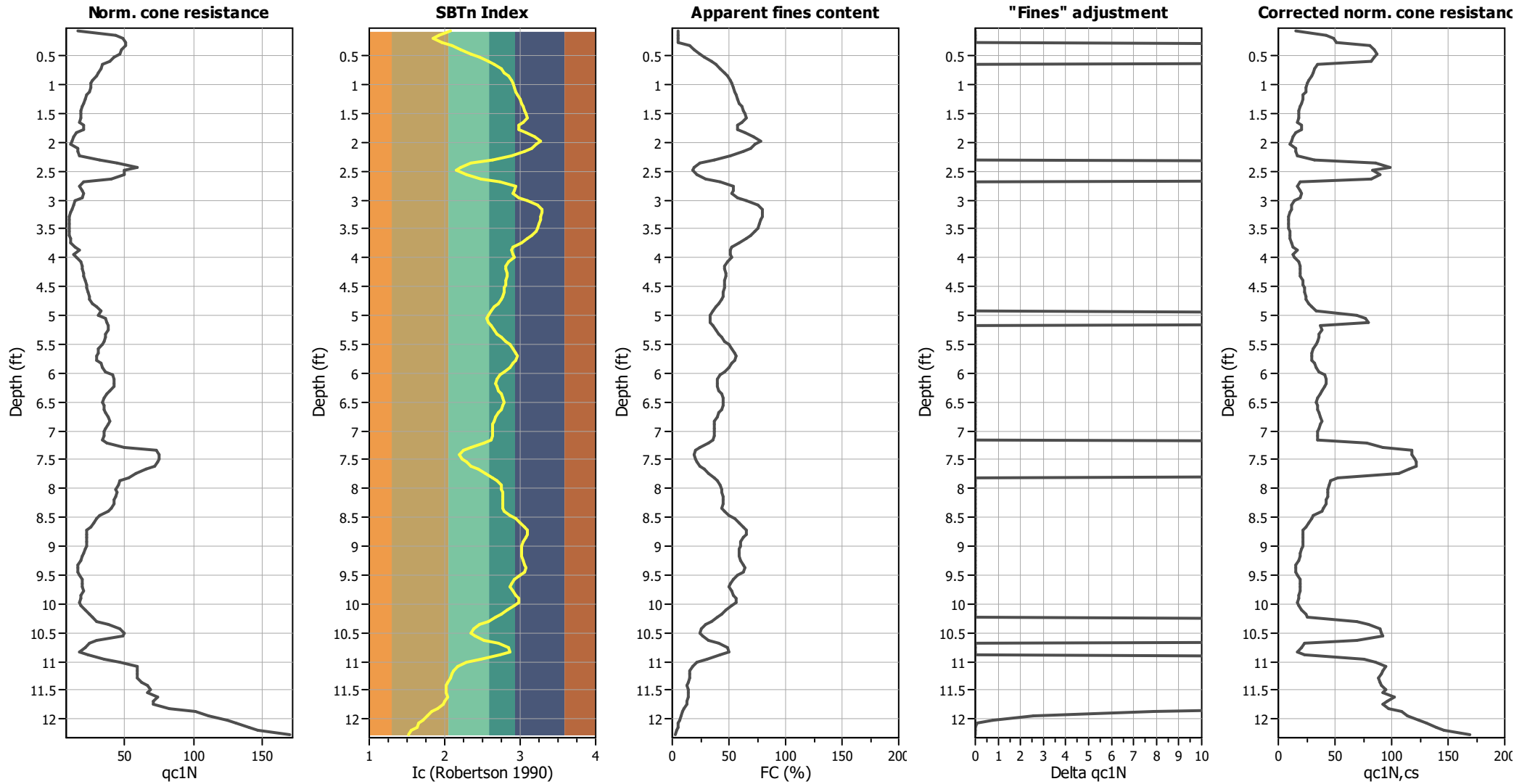
#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>q</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

#### SBTn legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

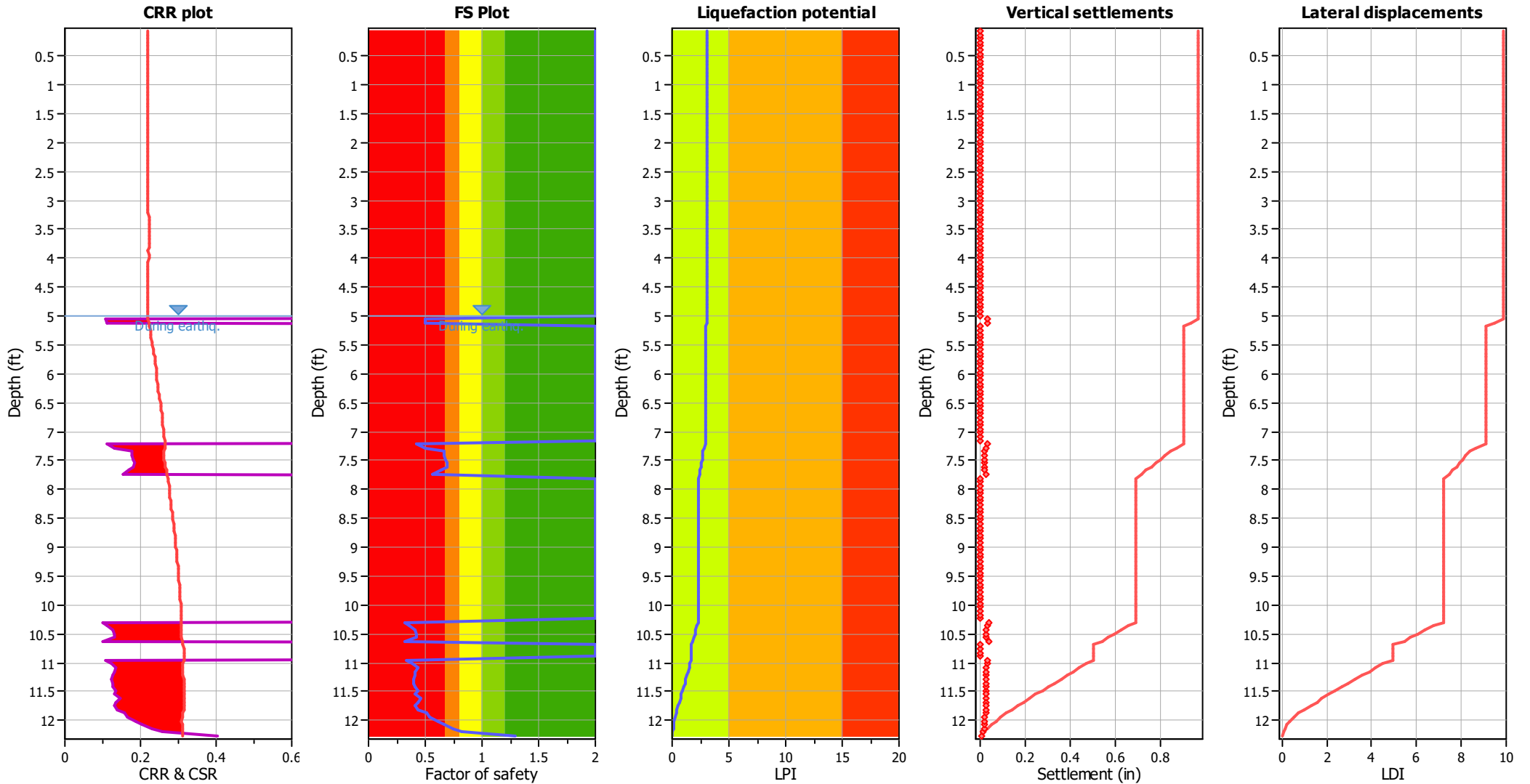
### Liquefaction analysis overall plots (intermediate results)



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (earthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

### Liquefaction analysis overall plots



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	$K_d$ applied:	Yes
Earthquake magnitude $M_w$ :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

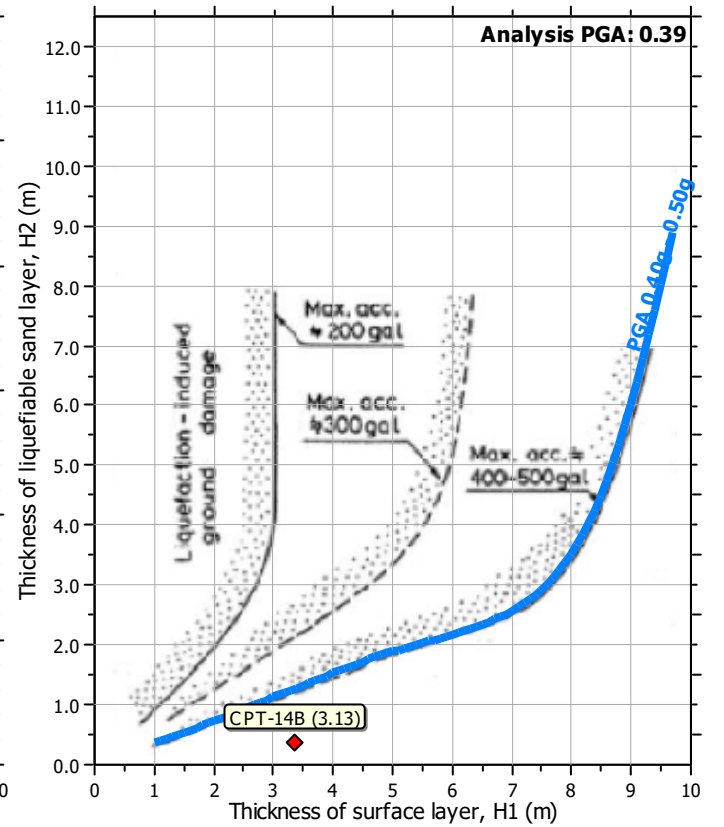
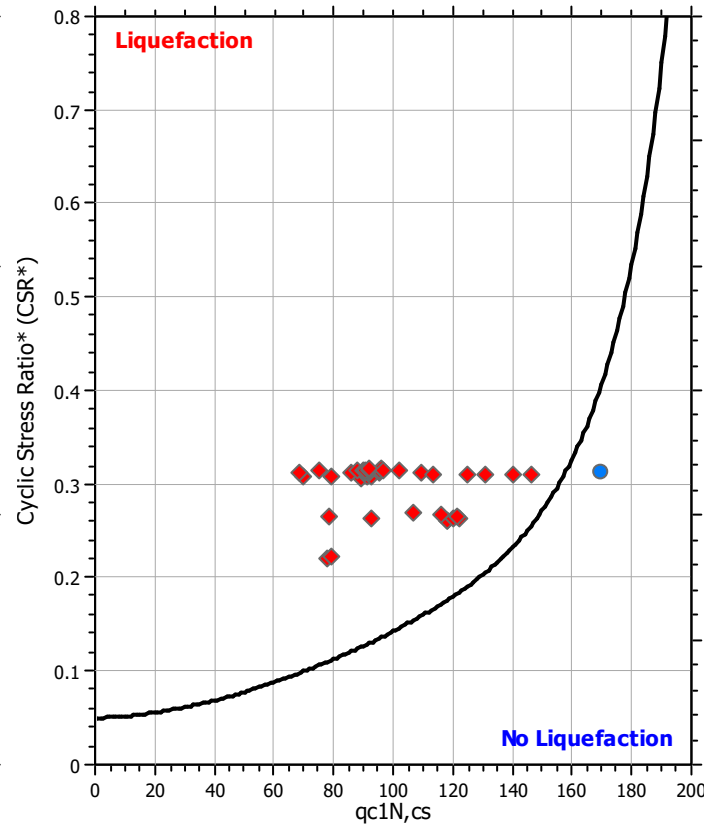
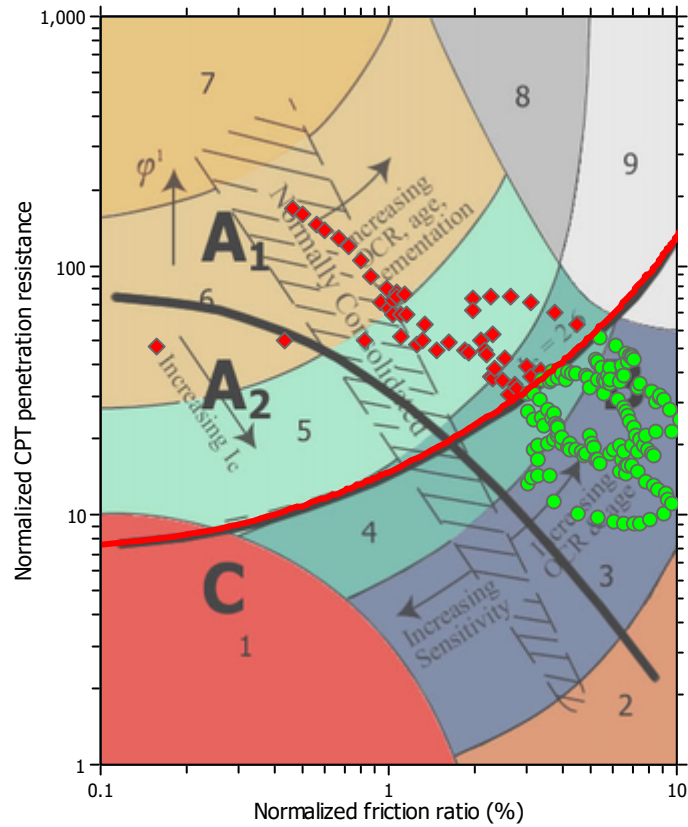
#### F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

#### LPI color scheme

- Very high risk
- High risk
- Low risk

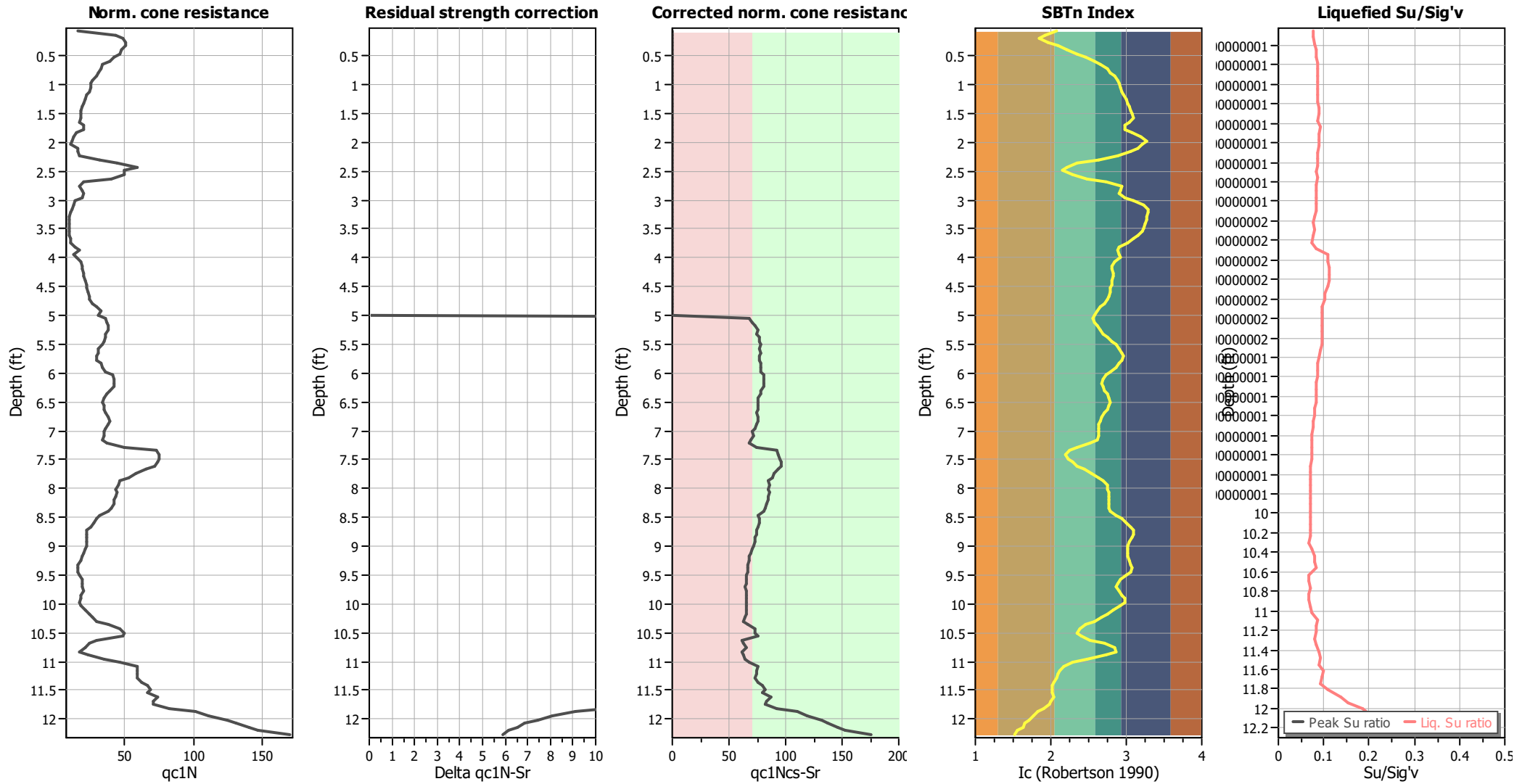
### Liquefaction analysis summary plots



**Input parameters and analysis data**

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>0</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A

### Check for strength loss plots (Idriss & Boulanger (2008))



#### Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	5.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K <sub>σ</sub> applied:	Yes
Earthquake magnitude M <sub>w</sub> :	7.28	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.39	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	5.00 ft	Fill height:	N/A	Limit depth:	N/A



# Seismic Analysis Reinforced - FS Pile Shear Reinforcement set to 0 lb



Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Material Dependent	Adhesion (psf)	Friction Angle (deg)	Shear Strength Model	Failure Mode	Pile Shear Strength (lbs)	Force Direction	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (lbs/ft)
Mirafi PET 1000 MD	Blue	Geosynthetic	Active (Method A)		No	0	21	Linear				Parallel to Reinforcement	None	100	22800
Timber pile	Purple	Pile/Micro Pile	Active (Method A)	3.5					Shear	0	Perpendicular to pile				
Timber Pile 2	Pink	Pile/Micro Pile	Active (Method A)	3.5					Shear	0	Perpendicular to pile				
Mirafi PET 1000 CD	Cyan	Geosynthetic	Active (Method A)		No	0	21	Linear				Parallel to Reinforcement	None	100	900

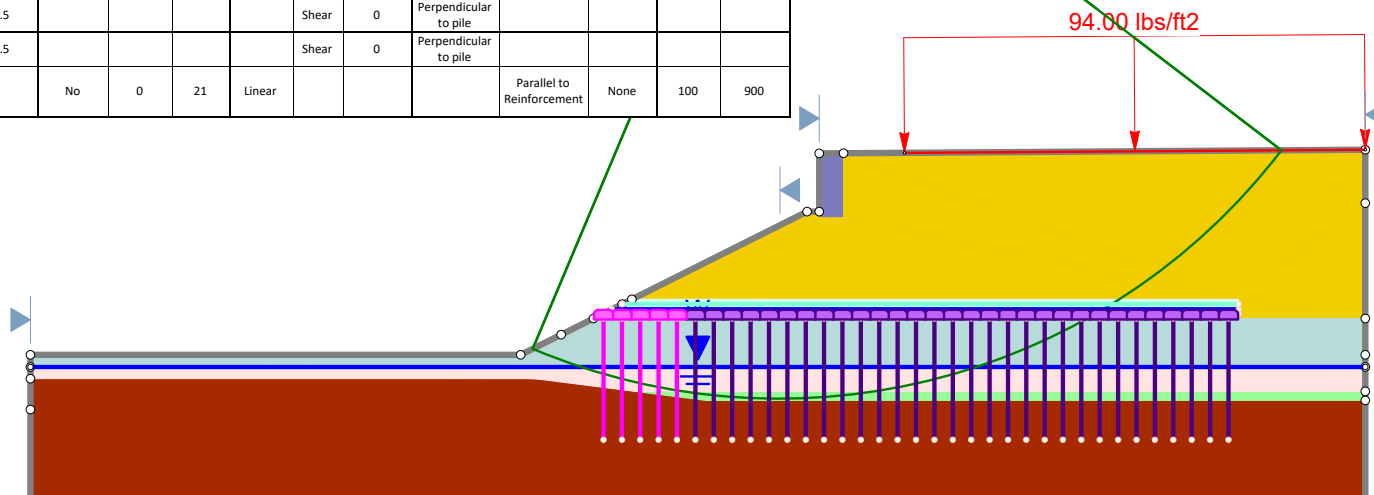
Method Name	Min FS
Spencer	0.791

250

200

150

100



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
New Embankment Undrained	Yellow	120	Mohr-Coulomb	500	9
Abutment	Blue	1	Infinite strength		
PWR	Olive	120	Mohr-Coulomb	8000	0
Residual ML/CL	Brown	120	Mohr-Coulomb	3500	0
Alluvial CL Softening	Pink	120	Mohr-Coulomb	1200	0
Alluvial Sand-Like Liquefied	Light Green	120	Mohr-Coulomb	0	7

-200    -175    -150    -125    -100    -75    -50    -25    0    25    50    75    100



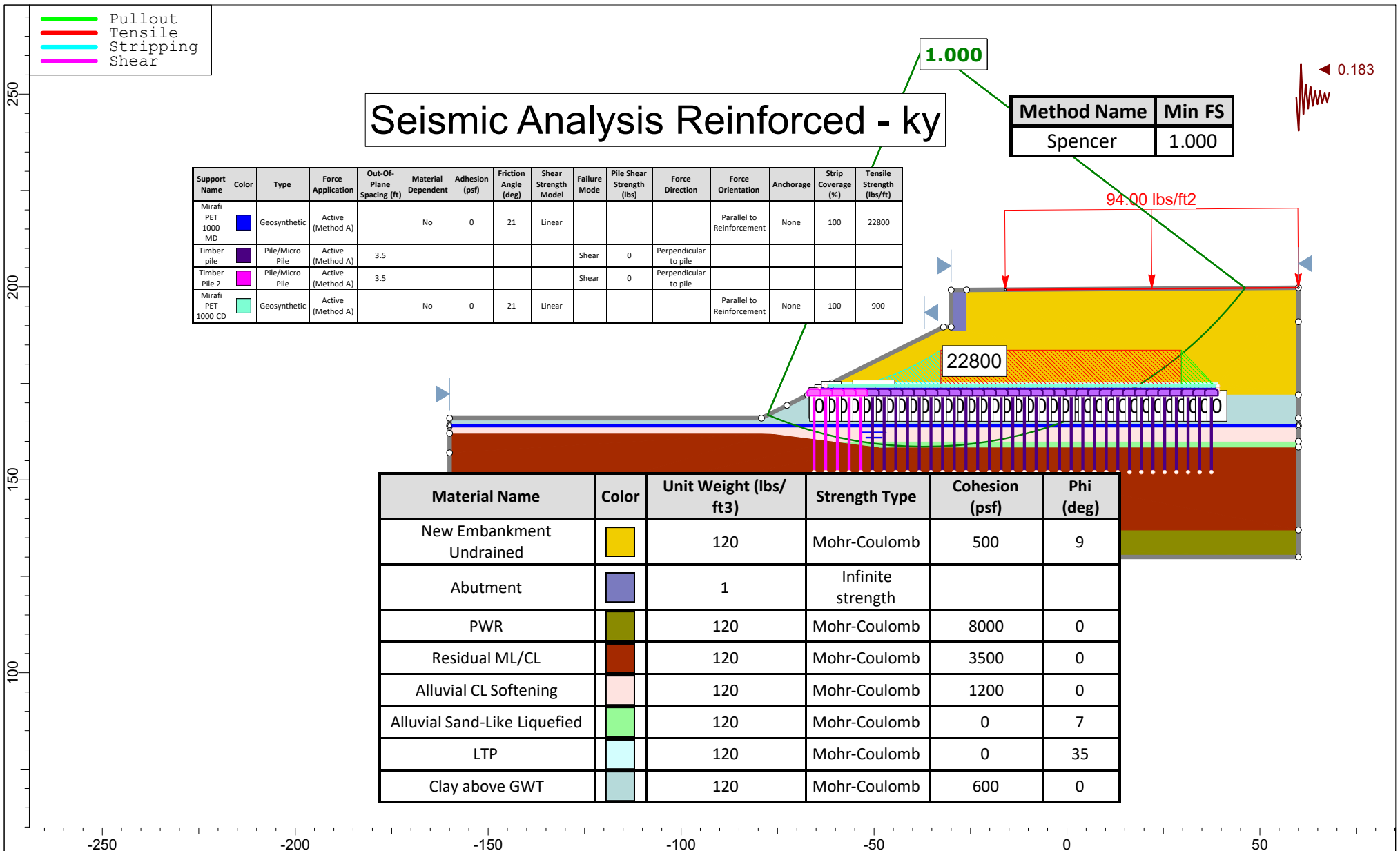
Project	CCRP1	
Group	Seismic Analysis Reinforced	Scenario kh
Drawn By	SGT	Company ICE
		File Name Bridge 35 End Bent 1 Embankment Front Slope As Built.slmd

- Pullout
- Tensile
- Stripping
- Shear

# Seismic Analysis Reinforced - ky

Method Name	Min FS
Spencer	1.000

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Material Dependent	Adhesion (psf)	Friction Angle (deg)	Shear Strength Model	Failure Mode	Pile Shear Strength (lbs)	Force Direction	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (lbs/ft)
Mirafi PET 1000 MD		Geosynthetic	Active (Method A)		No	0	21	Linear				Parallel to Reinforcement	None	100	22800
Timber pile		Pile/Micro Pile	Active (Method A)	3.5					Shear	0	Perpendicular to pile				
Timber Pile 2		Pile/Micro Pile	Active (Method A)	3.5					Shear	0	Perpendicular to pile				
Mirafi PET 1000 CD		Geosynthetic	Active (Method A)		No	0	21	Linear				Parallel to Reinforcement	None	100	900



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
New Embankment Undrained		120	Mohr-Coulomb	500	9
Abutment		1	Infinite strength		
PWR		120	Mohr-Coulomb	8000	0
Residual ML/CL		120	Mohr-Coulomb	3500	0
Alluvial CL Softening		120	Mohr-Coulomb	1200	0
Alluvial Sand-Like Liquefied		120	Mohr-Coulomb	0	7
LTP		120	Mohr-Coulomb	0	35
Clay above GWT		120	Mohr-Coulomb	600	0

	<i>Project</i> CCRP1	
	<i>Group</i> Seismic Analysis Reinforced	<i>Scenario</i> ky
	<i>Drawn By</i> SGT	<i>Company</i> ICE
	<i>File Name</i> Bridge 35 End Bent 1 Embankment Front Slope As Built.slmd	

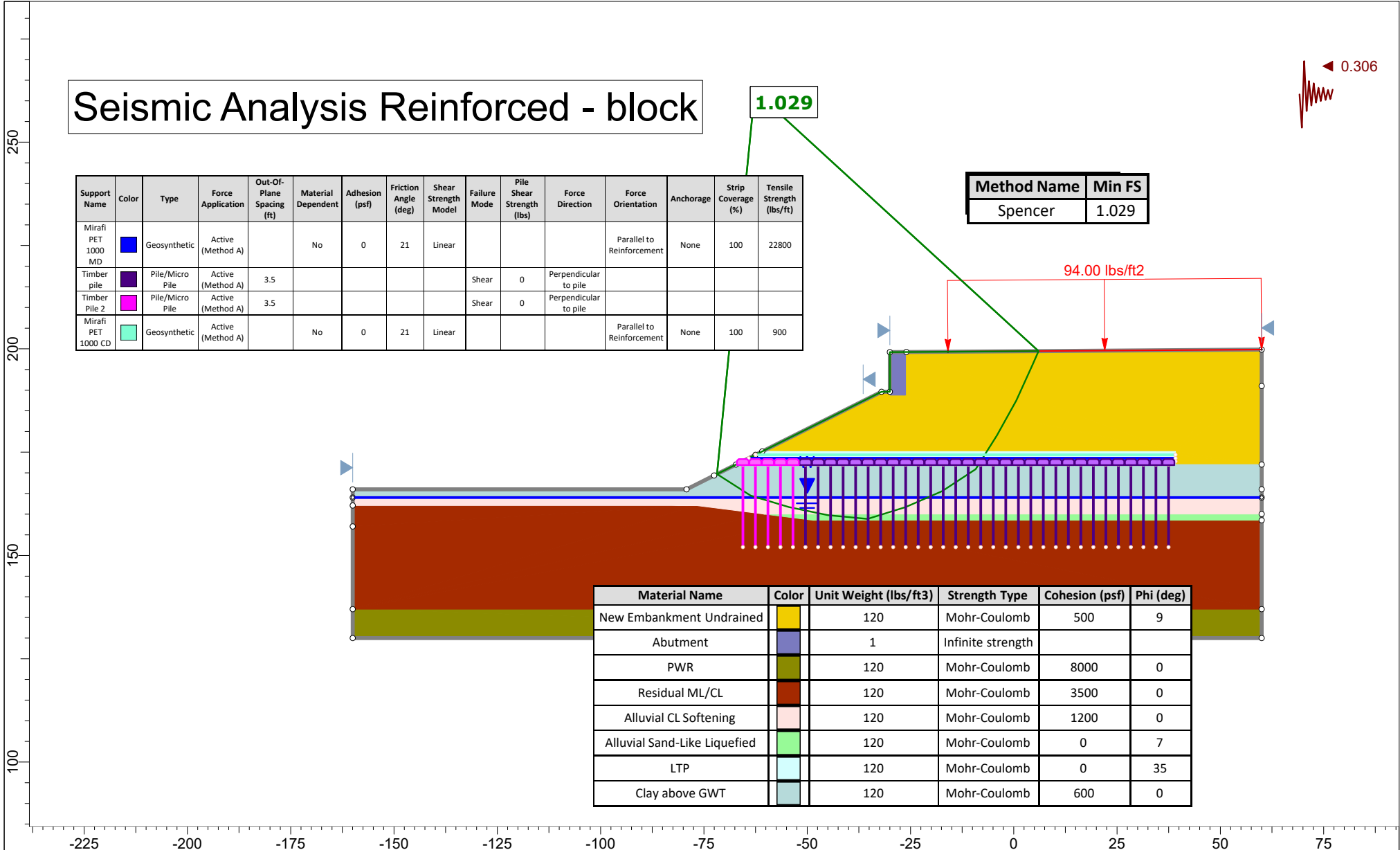
# Seismic Analysis Reinforced - block

0.306

1.029

Method Name	Min FS
Spencer	1.029

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Material Dependent	Adhesion (psf)	Friction Angle (deg)	Shear Strength Model	Failure Mode	Pile Shear Strength (lbs)	Force Direction	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (lbs/ft)
Mirafi PET 1000 MD	Blue	Geosynthetic	Active (Method A)		No	0	21	Linear				Parallel to Reinforcement	None	100	22800
Timber pile	Purple	Pile/Micro Pile	Active (Method A)	3.5					Shear	0	Perpendicular to pile				
Timber Pile 2	Pink	Pile/Micro Pile	Active (Method A)	3.5					Shear	0	Perpendicular to pile				
Mirafi PET 1000 CD	Light Green	Geosynthetic	Active (Method A)		No	0	21	Linear				Parallel to Reinforcement	None	100	900



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
New Embankment Undrained	Yellow	120	Mohr-Coulomb	500	9
Abutment	Blue	1	Infinite strength		
PWR	Olive Green	120	Mohr-Coulomb	8000	0
Residual ML/CL	Brown	120	Mohr-Coulomb	3500	0
Alluvial CL Softening	Light Pink	120	Mohr-Coulomb	1200	0
Alluvial Sand-Like Liquefied	Light Green	120	Mohr-Coulomb	0	7
LTP	Light Blue	120	Mohr-Coulomb	0	35
Clay above GWT	Dark Blue	120	Mohr-Coulomb	600	0



Project	CCRP1		
Group	Seismic Analysis Reinforced	Scenario	kh Block
Drawn By	SGT	Company	ICE
		File Name	Bridge 35 End Bent 1 Embankment Front Slope As Built.slm

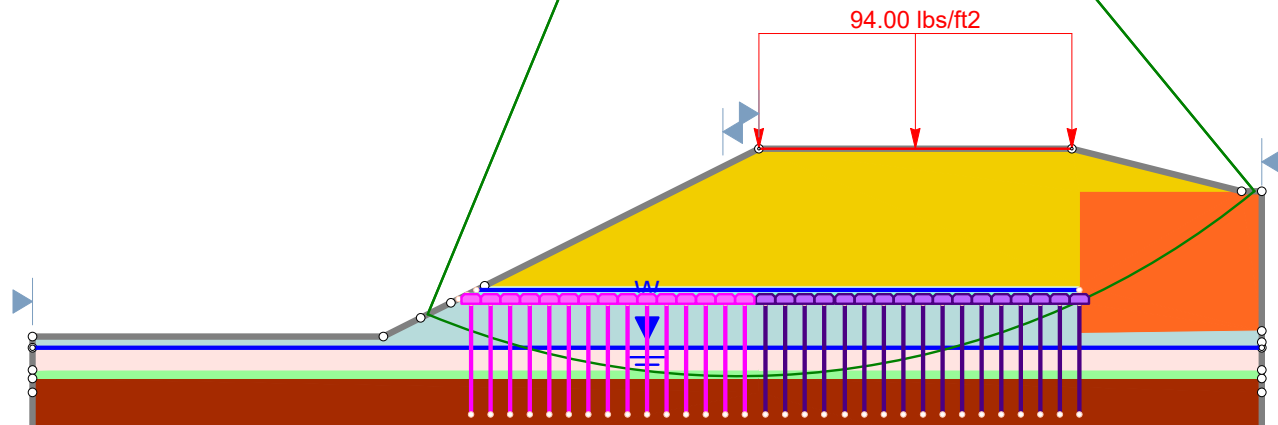
# Seismic Analysis Reinforced - kh

0.667

0.306

Method Name	Min FS
Spencer	0.667

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Material Dependent	Adhesion (psf)	Friction Angle (deg)	Shear Strength Model	Failure Mode	Pile Shear Strength (lbs)	Force Direction	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (lbs/ft)
Mirafi PET 1000 MD	Blue	Geosynthetic	Active (Method A)		No	0	21	Linear				Parallel to Reinforcement	None	100	22800
Timber Pile	Purple	Pile/Micro Pile	Active (Method A)	3.03					Shear	0	Perpendicular to pile				
Timber Pile 2	Pink	Pile/Micro Pile	Active (Method A)	3.03					Shear	0	Perpendicular to pile				
Mirafi PET 1000 CD	Light Green	Geosynthetic	Active (Method A)		No	0	21	Linear				Parallel to Reinforcement	None	100	900



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
New Embankment Undrained	Yellow	120	Mohr-Coulomb	500	9
Existing Roadway Embankment - Undrained	Orange	120	Mohr-Coulomb	500	15
Residual ML/CL	Brown	120	Mohr-Coulomb	3500	0
Alluvial CL Softening	Light Brown	120	Mohr-Coulomb	1200	0
Alluvial SM/ML Liquefied	Light Green	120	Mohr-Coulomb	0	7
LTP	Light Blue	120	Mohr-Coulomb	0	35
Clay Above GW	Dark Blue	120	Mohr-Coulomb	600	0



Project	CCRP1		
Group	Seismic Analysis Reinforced	Scenario	kh
Drawn By	SGT	Company	ICE
		File Name	Bridge 35 End Bent 1 Embankment As Built.slm

- Pullout
- Tensile
- Stripping
- Shear

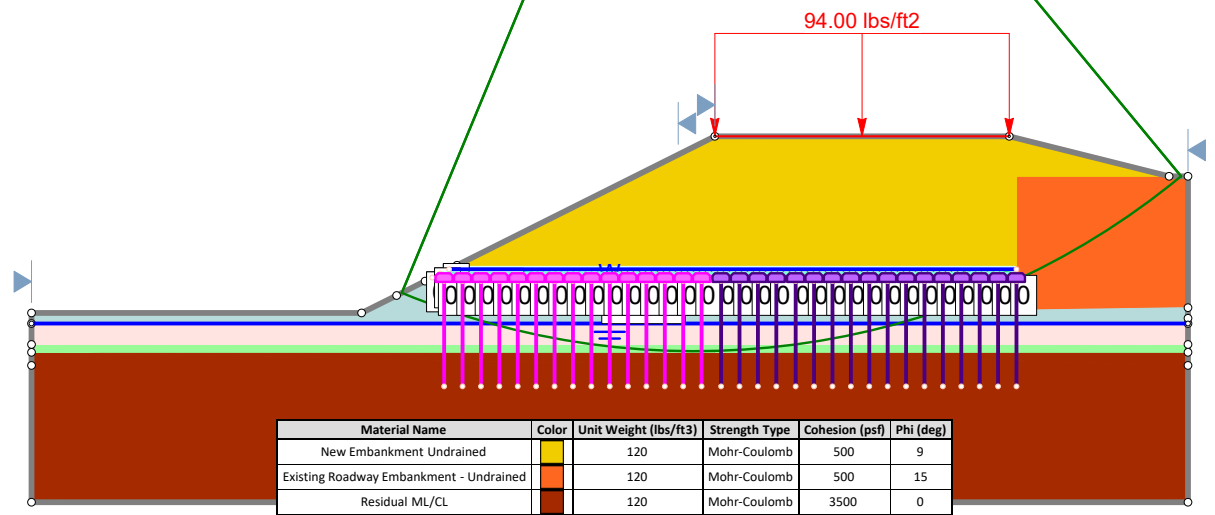


# Seismic Analysis Reinforced - ky

0.999

Method Name	Min FS
Spencer	0.999

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Material Dependent	Adhesion (psf)	Friction Angle (deg)	Shear Strength Model	Failure Mode	Pile Shear Strength (lbs)	Force Direction	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (lbs/ft)
Mirafi PET 1000 MD	Blue	Geosynthetic	Active (Method A)		No	0	21	Linear				Parallel to Reinforcement	None	100	22800
Timber Pile	Dark Purple	Pile/Micro Pile	Active (Method A)	3.03					Shear	0	Perpendicular to pile				
Timber Pile 2	Magenta	Pile/Micro Pile	Active (Method A)	3.03					Shear	0	Perpendicular to pile				
Mirafi PET 1000 CD	Cyan	Geosynthetic	Active (Method A)		No	0	21	Linear				Parallel to Reinforcement	None	100	900



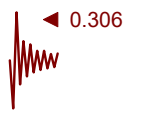
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
New Embankment Undrained	Yellow	120	Mohr-Coulomb	500	9
Existing Roadway Embankment - Undrained	Orange	120	Mohr-Coulomb	500	15
Residual ML/CL	Brown	120	Mohr-Coulomb	3500	0
Alluvial CL Softening	Light Brown	120	Mohr-Coulomb	1200	0
Alluvial SM/ML Liquefied	Light Green	120	Mohr-Coulomb	0	7
LTP	Light Blue	120	Mohr-Coulomb	0	35
Clay Above GW	Dark Blue	120	Mohr-Coulomb	600	0



Project	CCRP1		
Group	Seismic Analysis Reinforced	Scenario	ky
Drawn By	SGT	Company	ICE
		File Name	Bridge 35 End Bent 1 Embankment As Built.slmd

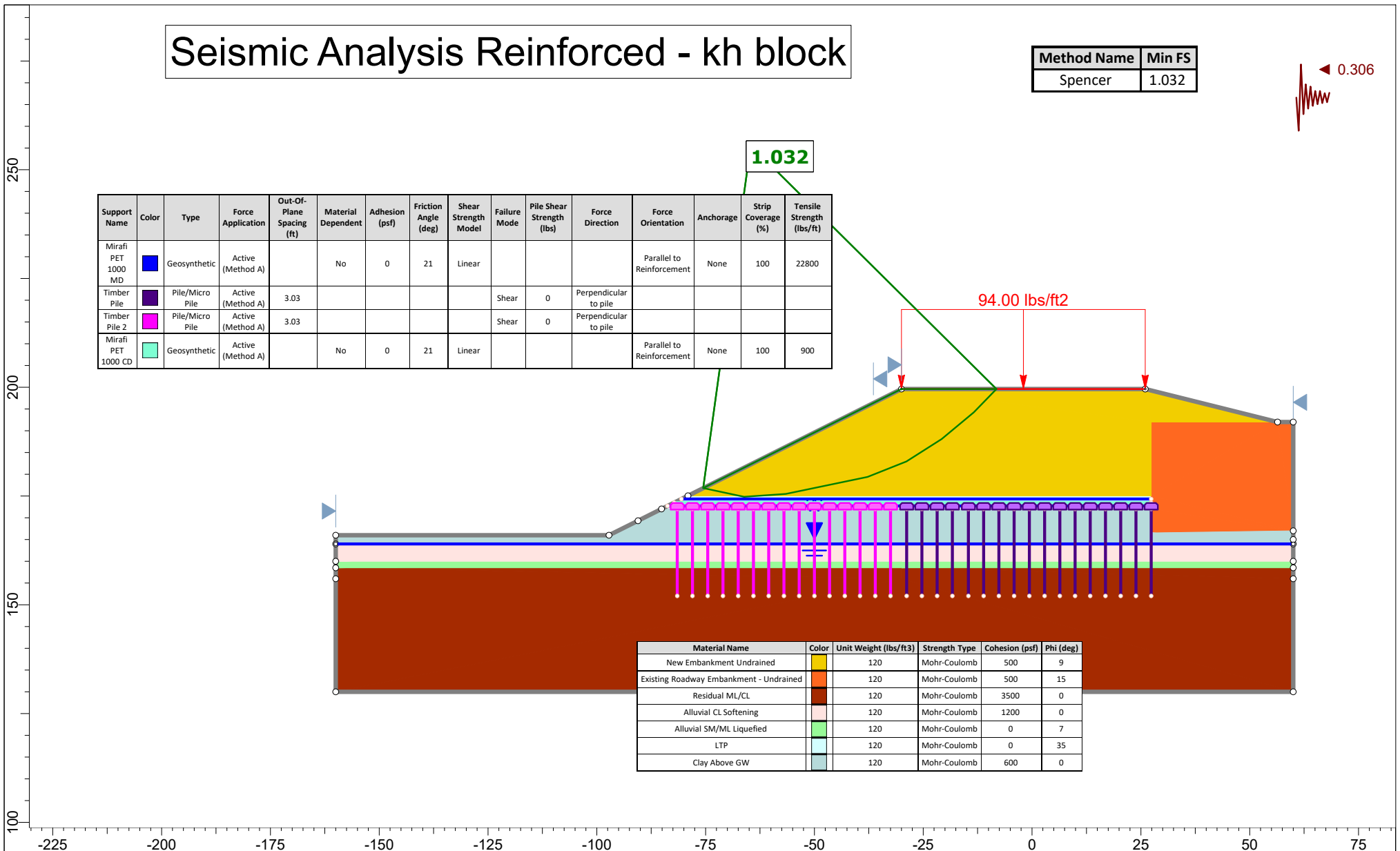
# Seismic Analysis Reinforced - kh block

Method Name	Min FS
Spencer	1.032



1.032

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Material Dependent	Adhesion (psf)	Friction Angle (deg)	Shear Strength Model	Failure Mode	Pile Shear Strength (lbs)	Force Direction	Force Orientation	Anchorage	Strip Coverage (%)	Tensile Strength (lbs/ft)
Mirafi PET 1000 MD	Blue	Geosynthetic	Active (Method A)		No	0	21	Linear				Parallel to Reinforcement	None	100	22800
Timber Pile	Purple	Pile/Micro Pile	Active (Method A)	3.03					Shear	0	Perpendicular to pile				
Timber Pile Z	Pink	Pile/Micro Pile	Active (Method A)	3.03					Shear	0	Perpendicular to pile				
Mirafi PET 1000 CD	Light Blue	Geosynthetic	Active (Method A)		No	0	21	Linear				Parallel to Reinforcement	None	100	900



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
New Embankment Undrained	Yellow	120	Mohr-Coulomb	500	9
Existing Roadway Embankment - Undrained	Orange	120	Mohr-Coulomb	500	15
Residual ML/CL	Brown	120	Mohr-Coulomb	3500	0
Alluvial CL Softening	Light Brown	120	Mohr-Coulomb	1200	0
Alluvial SM/ML Liquefied	Light Green	120	Mohr-Coulomb	0	7
LTP	Light Blue	120	Mohr-Coulomb	0	35
Clay Above GW	Dark Blue	120	Mohr-Coulomb	600	0



Project	CCRP1		
Group	Seismic Analysis Reinforced	Scenario	kh Block
Drawn By	SGT	Company	ICE
		File Name	Bridge 35 End Bent 1 Embankment As Built.slm



**Seismic Global Stability Evaluation**

Slope Deformations w Timber Pile Compatibility

Design Earthquake Case	SEE
PGA	0.39 g
$S_{D1}$	0.28 g
PGV	10.7 in/sec

wave scattering scaling factor $\alpha_w$	0.785	0.785
$\beta$	0.718	0.718
slope height H (ft)	33.6	33.6
$k_h$	0.306	0.306

**Evaluation of Seismic Instability**

	Front	Side Slope
Horizontal yield acceleration $k_y$	0.183	0.156
ratio $k_y/k_h$	0.598	0.510

Residual Displacement		
log d	-0.23447812	0.0102655
displacement d	0.582803132	1.02391876

**Lpile Analysis**

Check Pile for Side Slope Deformation of 1"

	Shear in Pile within SSL Layer (kip)	Maximum Shear in Pile (kip)	Maximum Moment in Pile (in-lb)	Maximum Moment in Pile (ft-kip)	Depth of Max Moment (ft)	Pile Diameter at Max Moment (in)	Horizontal yield acceleration ( $k_y$ )	Resulting Newmark Displacement (in)
L-Pile Input Ground Displacement								
1	8387	8387	213500	17.7916667	9.9	10.5		



PM:	Michael Valiquette, P.E.	SCDOT Project Number:	P039718	<b>BRIDGE EMBANKMENT STABILITY ANALYSIS</b> <b>BRIDGE 35 END BENT 1 FRONT SLOPE</b> CCRP1 Bridge 35 Walls/Fills Lexington/Richland Cos., South Carolina
Calculated By:	Michael Valiquette, P.E.	ICE Project Number:	20-61	
Checked By:		Revision:	0	
Approved By:	Michael Valiquette, P.E.	Date:	6/21/2023	

**Project:** CCRP1 - Bridge 35 Timber Pile Ground Mods - As Built  
**Subject:** Combined Bending and Axial Compression Check  
**By:** MDV **Chk'd By:** MDV  
**Date:** 6/21/2023 **Date:** 6/21/2023



The following spreadsheet checks combined flexure and axial compression of timber piles in accordance with AASHTO LRFD 8th Edition. Piles are used as ground modification for the Extreme Event load case, so load and resistance factors are equal to 1.0. Spreadsheet assumes Southern Pine for all parameters.

Front Slope Piles - Max Fill Height - Boring EB1-RT

**Input Parameters:**

Pile Diameter =	9.5 in	<b>OK</b>	Perf. Ratio =	0.57
Axial Load, P =	36.4 kips		Max Axial Load in Pile, Extreme Event Surcharge, No LL	
Moment, M =	17.8 kip-ft		Worst Case Moment from All Slope Cases	

**Calculations:**

Factored Axial Load,  $P_u$  = 36.4 kips  
 Factored Moment,  $M_u$  = 213.5 kip-in  
 Gross Area of Pile,  $A_g$  = 70.9 in<sup>2</sup>

Compression Parallel to Grain:

Column Stability Factor, $C_p$ =	1.00	<i>Assumes Pile is Adequately Braced by Surrounding Soil</i>
$F_c$ =	2.40 ksi	<i>LRFD Eq. 8.4.4.1-4</i>
$F_{co}$ =	1.20 ksi	<i>LRFD Table 8.4.1.4-1</i>
$C_{KF}$ =	2.50	<i>LRFD Section 8.4.4.2</i>
$C_M$ =	1.00	<i>1.0 for Southern pine 5x5 and larger (LRFD Section 8.4.4.3)</i>
$C_F$ =	1.00	<i>LRFD Eq. 8.4.4.4-1 &amp; 8.4.4.4-2</i>
$C_i$ =	0.80	<i>LRFD Table 8.4.4.7-1</i>
$C_\lambda$ =	1.00	<i>1.0 for Extreme Event (LRFD Table 8.4.4.7-1)</i>
Compressive Resistance, $P_r$ =	170.1 kips	<i>LRFD Eq. 8.8.1-1 &amp; 8.8.2-1</i>

Flexure:

Section Modulus, $S$ =	84.2 in <sup>3</sup>	$Pi * d^3 / 32$
$F_b$ =	4.80 ksi	<i>LRFD Eq. 8.4.4.1-1</i>
$F_{bo}$ =	2.40 ksi	<i>LRFD Table 8.4.1.4-1</i>
$C_{KF}$ =	2.5	
$C_M$ =	1.00	<i>1.0 for Southern pine 5x5 and larger (LRFD Section 8.4.4.3)</i>
$C_F$ =	1.00	<i>LRFD Eq. 8.4.4.4-1 &amp; 8.4.4.4-2</i>
$C_{fu}$ =	1.00	<i>Flat Use Factor (not applicable)</i>
$C_i$ =	0.80	<i>LRFD Table 8.4.4.7-1</i>
$C_d$ =	1.00	<i>LRFD Section 8.4.4.8</i>
$C_\lambda$ =	1.00	<i>1.0 for Extreme Event (LRFD Table 8.4.4.7-1)</i>
Flexural Resistance, $M_r$ =	404.0 kip-in 33.7 kip-ft	<i>For Circular Section (LRFD Eq. 8.6.1-1 &amp; 8.6.3-1)</i>

Combined Flexure and Compressive Resistance:

$K_{CE}$ =	0.76	<i>0.76 for Round Piles (LRFD Section 8.8.2)</i>
$E$ =	1425 ksi	
$E_o$ =	1500 ksi	<i>LRFD Table 8.4.1.4-1</i>
$C_M$ =	1.00	<i>1.0 for Southern pine 5x5 and larger (LRFD Section 8.4.4.3)</i>
$C_i$ =	0.95	<i>LRFD Table 8.4.4.7-1</i>
$L_e$ =	1.00 in	<i>Use 1" since Timber Pile is continuously supported by soil</i>
$F_{CE}$ =	97740.75 ksi	<i>LRFD Eq. 8.8.2-4</i>

$(P_u/P_r)^2 + M_u/(M_r * (1 - P_u/F_{CE}A_g)) =$	0.57 ≤ 1.0	<b>OK</b>	<i>LRFD Eq. 8.10.2-1</i>
---	------------	-----------	--------------------------

=====  
LPIle for Windows(Beta), Version 2018-10.009

Analysis of Individual Piles and Drilled Shafts  
Subjected to Lateral Loading Using the p-y Method  
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-----  
Files Used for Analysis  
-----

Path to file locations:

\Projects\20-61 CCR Ph I\DESIGN and Construction Support\Construction Support\Timber Pile As Builts\

Name of input data file:

Bridge 35 EB 1 As Built Timber Pile Full Fill Max Displacement 1 inch as built.lp10

Name of output report file:

Bridge 35 EB 1 As Built Timber Pile Full Fill Max Displacement 1 inch as built.lp10

Name of plot output file:

Bridge 35 EB 1 As Built Timber Pile Full Fill Max Displacement 1 inch as built.lp10

Name of runtime message file:

Bridge 35 EB 1 As Built Timber Pile Full Fill Max Displacement 1 inch as built.lp10

-----  
Date and Time of Analysis  
-----

Date: June 21, 2023

Time: 18:57:58

-----  
Problem Title  
-----

CCRP1

20-61

SCDOT

SGT/MDV

-----  
 Program Options and Settings  
 -----

Computational Options:

- Use unfactored loads in computations (conventional analysis)

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 100

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Analysis includes loading by one lateral soil movement profile acting on pile
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

-----  
 Pile Structural Properties and Geometry  
 -----

- Number of pile sections defined = 1
- Total length of pile = 15.000 ft
- Depth of ground surface below top of pile = -28.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.0000
2	15.000	8.9000

Input Structural Properties for Pile Sections:  
 -----

Pile Section No. 1:

Section 1 is an elastic pile  
Cross-sectional Shape = Circular Pile  
Length of section = 15.000000 ft  
Width of top of section = 12.000000 in  
Width of bottom of section = 8.900000 in  
Top Area = 113.097336 sq. in  
Bottom Area = 62.211389 sq. in  
Moment of Inertia at Top = 1018. in^4  
Moment of Inertia at Bottom = 307.985255 in^4  
Elastic Modulus = 1500000. psi

-----  
Ground Slope and Pile Batter Angles  
-----

Ground Slope Angle = 0.000 degrees  
= 0.000 radians  
Pile Batter Angle = 0.000 degrees  
= 0.000 radians

-----  
Soil and Rock Layering Information  
-----

The soil profile is modelled using 5 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = -28.000000 ft  
Distance from top of pile to bottom of layer = 0.0000 ft  
Effective unit weight at top of layer = 120.000000 pcf  
Effective unit weight at bottom of layer = 120.000000 pcf  
Friction angle at top of layer = 30.000000 deg.  
Friction angle at bottom of layer = 30.000000 deg.  
Subgrade k at top of layer = 0.0000 pci  
Subgrade k at bottom of layer = 0.0000 pci

NOTE: Default values for subgrade k will be computed for this layer.

Layer 2 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer = 0.0000 ft  
Distance from top of pile to bottom of layer = 6.000000 ft  
Effective unit weight at top of layer = 120.000000 pcf  
Effective unit weight at bottom of layer = 120.000000 pcf  
Undrained cohesion at top of layer = 600.000000 psf  
Undrained cohesion at bottom of layer = 600.000000 psf  
Epsilon-50 at top of layer = 0.0000  
Epsilon-50 at bottom of layer = 0.0000

NOTE: Default values for Epsilon-50 will be computed for this layer.

Layer 3 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer = 6.000000 ft  
Distance from top of pile to bottom of layer = 11.500000 ft  
Effective unit weight at top of layer = 58.000000 pcf  
Effective unit weight at bottom of layer = 58.000000 pcf  
Undrained cohesion at top of layer = 1200. psf  
Undrained cohesion at bottom of layer = 1200. psf

Epsilon-50 at top of layer = 0.0000  
 Epsilon-50 at bottom of layer = 0.0000

NOTE: Default values for Epsilon-50 will be computed for this layer.

Layer 4 is sand, p-y criteria by API RP-2A, 1987

Distance from top of pile to top of layer = 11.500000 ft  
 Distance from top of pile to bottom of layer = 13.000000 ft  
 Effective unit weight at top of layer = 58.000000 pcf  
 Effective unit weight at bottom of layer = 58.000000 pcf  
 Friction angle at top of layer = 20.000000 deg.  
 Friction angle at bottom of layer = 20.000000 deg.  
 Subgrade k at top of layer = 0.0000 pci  
 Subgrade k at bottom of layer = 0.0000 pci

NOTE: Default values for subgrade k will be computed for this layer.

Layer 5 is stiff clay without free water

Distance from top of pile to top of layer = 13.000000 ft  
 Distance from top of pile to bottom of layer = 40.000000 ft  
 Effective unit weight at top of layer = 58.000000 pcf  
 Effective unit weight at bottom of layer = 58.000000 pcf  
 Undrained cohesion at top of layer = 3500. psf  
 Undrained cohesion at bottom of layer = 3500. psf  
 Epsilon-50 at top of layer = 0.0000  
 Epsilon-50 at bottom of layer = 0.0000

NOTE: Default values for Epsilon-50 will be computed for this layer.

(Depth of the lowest soil layer extends 25.000 ft below the pile tip)

-----  
 Summary of Input Soil Properties  
 -----

Layer Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	E50 or krm	kpy pci
1	Sand	-28.0000	120.0000	--	30.0000	--	default
	(Reese, et al.)	0.00	120.0000	--	30.0000	--	default
2	Soft	0.00	120.0000	600.0000	--	default	--
	Clay	6.0000	120.0000	600.0000	--	default	--
3	Soft	6.0000	58.0000	1200.	--	default	--
	Clay	11.5000	58.0000	1200.	--	default	--
4	API	11.5000	58.0000	--	20.0000	--	default
	Sand	13.0000	58.0000	--	20.0000	--	default
5	Stiff Clay	13.0000	58.0000	3500.	--	default	--
	w/o Free Water	40.0000	58.0000	3500.	--	default	--

-----  
 p-y Modification Factors for Group Action  
 -----

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.5400	1.0000
2	16.000	0.5400	1.0000

-----  
 Lateral Soil Movements Applied to All Load Cases  
 -----

Profile of soil movement with depth defined using 4 points

Point No.	Depth X ft	Soil Movement in
1	-28.00000	1.00000
2	0.00000	1.00000
3	11.50000	1.00000
4	13.00000	0.00000

-----  
 Static Loading Type  
 -----

Static loading criteria were used when computing p-y curves for all analyses.

-----  
 Pile-head Loading and Pile-head Fixity Conditions  
 -----

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	36364.	No

V = shear force applied normal to pile axis  
 M = bending moment applied to pile head  
 y = lateral deflection normal to pile axis  
 S = pile slope relative to original pile batter angle  
 R = rotational stiffness applied to pile head  
 Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).  
 Thrust force is assumed to be acting axially for all pile batter angles.

-----  
 Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness  
 -----

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:  
 -----

Moment-curvature properties were derived from elastic section properties

-----  
 Layering Correction Equivalent Depths of Soil & Rock Layers  
 -----

Top of Layer	Equivalent Top Depth	Same Layer	Layer is	F0	F1
--------------	----------------------	------------	----------	----	----



Layer No.	Below Pile Head ft	Below Grnd Surf ft	Type As Layer Above	Rock or is Below Rock Layer	Integral for Layer lbs	Integral for Layer lbs
1	-28.0000	0.00	N.A.	No	0.00	1106634.
2	0.00	207.7893	No	No	1106634.	30774.
3	6.0000	120.4936	Yes	No	1137408.	50404.
4	11.5000	58.7441	No	No	1187812.	40694.
5	13.0000	53.2116	No	No	1228507.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

-----  
 Computed Values of Pile Loading and Deflection  
 for Lateral Loading for Load Case Number 1  
 -----

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs  
 Applied moment at pile head = 0.0 in-lbs  
 Axial thrust load on pile head = 36364.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.9954	1.62E-06	-3.14E-08	6.50E-04	321.5284	1.53E+09	30.1006	5953.	0.00
0.1500	0.9966	6.2405	51.5904	6.50E-04	323.2331	1.53E+09	27.2221	14490.	0.00
0.3000	0.9978	100.6802	97.3309	6.50E-04	325.4795	1.50E+09	23.6007	19204.	0.00
0.4500	0.9990	271.5781	135.0954	6.50E-04	328.2092	1.48E+09	18.3599	31698.	0.00
0.6000	1.0001	501.9405	143.6210	6.50E-04	331.3301	1.46E+09	-8.8871	125360.	0.00
0.7500	1.0013	703.4684	117.9876	6.51E-04	334.3099	1.45E+09	-19.5944	27154.	0.00
0.9000	1.0025	841.4532	78.5157	6.52E-04	336.9304	1.43E+09	-24.2633	17669.	0.00
1.0500	1.0036	900.7560	31.8546	6.53E-04	339.0886	1.42E+09	-27.5825	13615.	0.00
1.2000	1.0048	870.6167	-20.1768	6.54E-04	340.7056	1.40E+09	-30.2301	11281.	0.00
1.3500	1.0060	742.4589	-76.5997	6.55E-04	341.7140	1.39E+09	-32.4621	9735.	0.00
1.5000	1.0072	509.0610	-136.7810	6.56E-04	342.0531	1.38E+09	-34.4061	8622.	0.00
1.6500	1.0084	164.1438	-200.2689	6.57E-04	341.6664	1.36E+09	-36.1360	7776.	0.00
1.8000	1.0095	-297.8682	-266.7198	6.57E-04	344.3597	1.35E+09	-37.6984	7108.	0.00
1.9500	1.0107	-881.9970	-335.8609	6.56E-04	350.0232	1.33E+09	-39.1250	6565.	0.00
2.1000	1.0119	-1593.	-407.4675	6.54E-04	356.5971	1.32E+09	-40.4378	6113.	0.00
2.2500	1.0131	-2435.	-481.3493	6.51E-04	364.1307	1.30E+09	-41.6531	5731.	0.00
2.4000	1.0143	-3411.	-557.3415	6.47E-04	372.6723	1.29E+09	-42.7827	5403.	0.00
2.5500	1.0154	-4526.	-635.2981	6.42E-04	382.2696	1.28E+09	-43.8357	5119.	0.00
2.7000	1.0166	-5782.	-715.0872	6.34E-04	392.9698	1.26E+09	-44.8189	4871.	0.00
2.8500	1.0177	-7183.	-796.5877	6.25E-04	404.8196	1.25E+09	-45.7373	4652.	0.00
3.0000	1.0188	-8732.	-879.6867	6.14E-04	417.8657	1.23E+09	-46.5949	4458.	0.00
3.1500	1.0199	-10430.	-964.2769	5.99E-04	432.1541	1.22E+09	-47.3943	4286.	0.00
3.3000	1.0210	-12281.	-1050.	5.83E-04	447.7310	1.21E+09	-48.1376	4132.	0.00
3.4500	1.0220	-14287.	-1138.	5.63E-04	464.6420	1.20E+09	-48.8258	3994.	0.00
3.6000	1.0230	-16450.	-1226.	5.39E-04	482.9326	1.18E+09	-49.4594	3871.	0.00
3.7500	1.0239	-18772.	-1316.	5.12E-04	502.6481	1.17E+09	-50.0384	3762.	0.00
3.9000	1.0248	-21253.	-1406.	4.81E-04	523.8333	1.16E+09	-50.5621	3664.	0.00
4.0500	1.0257	-23896.	-1498.	4.46E-04	546.5329	1.14E+09	-51.0294	3577.	0.00
4.2000	1.0264	-26703.	-1590.	4.06E-04	570.7911	1.13E+09	-51.4387	3501.	0.00
4.3500	1.0271	-29673.	-1683.	3.61E-04	596.6514	1.12E+09	-51.7877	3435.	0.00
4.5000	1.0277	-32807.	-1776.	3.10E-04	624.1569	1.11E+09	-52.0738	3378.	0.00
4.6500	1.0283	-36107.	-1870.	2.54E-04	653.3499	1.09E+09	-52.2936	3331.	0.00
4.8000	1.0287	-39573.	-1964.	1.91E-04	684.2719	1.08E+09	-52.4431	3294.	0.00
4.9500	1.0289	-43204.	-2059.	1.22E-04	716.9633	1.07E+09	-52.5177	3266.	0.00
5.1000	1.0291	-47000.	-2153.	4.55E-05	751.4633	1.06E+09	-52.5118	3248.	0.00

5.2500	1.0291	-50961.	-2248.	-3.84E-05	787.8098	1.05E+09	-52.4188	3241.	0.00
5.4000	1.0290	-55087.	-2342.	-1.30E-04	826.0388	1.03E+09	-52.2310	3246.	0.00
5.5500	1.0286	-59375.	-2436.	-2.31E-04	866.1846	1.02E+09	-51.9388	3264.	0.00
5.7000	1.0281	-63825.	-2529.	-3.40E-04	908.2790	1.01E+09	-51.5312	3297.	0.00
5.8500	1.0274	-68434.	-2621.	-4.58E-04	952.3510	9.98E+08	-50.9943	3348.	0.00
6.0000	1.0265	-73201.	-2735.	-5.87E-04	998.4266	9.87E+08	-75.4667	5130.	0.00
6.1500	1.0253	-78203.	-2915.	-7.26E-04	1047.	9.76E+08	-124.6320	8865.	0.00
6.3000	1.0239	-83600.	-3137.	-8.76E-04	1100.	9.64E+08	-121.9945	9200.	0.00
6.4500	1.0222	-89381.	-3354.	-0.00104	1157.	9.53E+08	-118.7685	9651.	0.00
6.6000	1.0201	-95537.	-3564.	-0.00121	1218.	9.42E+08	-114.8213	10266.	0.00
6.7500	1.0178	-102052.	-3766.	-0.00140	1283.	9.31E+08	-109.9585	11130.	0.00
6.9000	1.0151	-108911.	-3959.	-0.00161	1352.	9.20E+08	-103.8776	12401.	0.00
7.0500	1.0120	-116093.	-4139.	-0.00183	1426.	9.10E+08	-96.0589	14420.	0.00
7.2000	1.0085	-123570.	-4302.	-0.00207	1503.	8.99E+08	-85.4614	18120.	0.00
7.3500	1.0045	-131309.	-4441.	-0.00233	1583.	8.89E+08	-69.2809	27447.	0.00
7.5000	1.0001	-139254.	-4523.	-0.00260	1667.	8.78E+08	-21.2966	323832.	0.00
7.6500	0.9952	-147250.	-4479.	-0.00290	1753.	8.68E+08	70.2473	26231.	0.00
7.8000	0.9897	-154998.	-4334.	-0.00321	1837.	8.57E+08	90.3708	15779.	0.00
7.9500	0.9836	-162432.	-4158.	-0.00355	1921.	8.47E+08	105.2677	11565.	0.00
8.1000	0.9769	-169503.	-3957.	-0.00390	2002.	8.37E+08	117.7785	9186.	0.00
8.2500	0.9696	-176167.	-3735.	-0.00428	2081.	8.27E+08	128.8983	7624.	0.00
8.4000	0.9615	-182390.	-3494.	-0.00467	2158.	8.17E+08	139.1020	6508.	0.00
8.5500	0.9528	-188135.	-3235.	-0.00508	2231.	8.07E+08	148.6548	5665.	0.00
8.7000	0.9432	-193371.	-2959.	-0.00551	2300.	7.98E+08	157.7198	5002.	0.00
8.8500	0.9329	-198068.	-2668.	-0.00595	2365.	7.88E+08	166.4039	4466.	0.00
9.0000	0.9218	-202195.	-2361.	-0.00641	2426.	7.78E+08	174.7807	4024.	0.00
9.1500	0.9099	-205726.	-2039.	-0.00689	2482.	7.69E+08	182.9023	3652.	0.00
9.3000	0.8970	-208633.	-1702.	-0.00737	2532.	7.60E+08	190.8068	3335.	0.00
9.4500	0.8833	-210889.	-1352.	-0.00787	2577.	7.50E+08	198.5223	3062.	0.00
9.6000	0.8687	-212469.	-987.7799	-0.00839	2615.	7.41E+08	206.0698	2825.	0.00
9.7500	0.8531	-213348.	-610.1984	-0.00891	2647.	7.32E+08	213.4652	2616.	0.00
9.9000	0.8366	-213500.	-219.4313	-0.00943	2672.	7.23E+08	220.7205	2432.	0.00
10.0500	0.8192	-212903.	184.2773	-0.00997	2690.	7.14E+08	227.8446	2268.	0.00
10.2000	0.8007	-211532.	600.6972	-0.01051	2699.	7.05E+08	234.8442	2121.	0.00
10.3500	0.7813	-209365.	1030.	-0.01105	2700.	6.96E+08	241.7241	1990.	0.00
10.5000	0.7610	-206379.	1471.	-0.01159	2692.	6.88E+08	248.4875	1871.	0.00
10.6500	0.7396	-202553.	1924.	-0.01213	2675.	6.79E+08	255.1365	1764.	0.00
10.8000	0.7173	-197865.	2389.	-0.01266	2648.	6.70E+08	261.6721	1666.	0.00
10.9500	0.6940	-192294.	2866.	-0.01319	2610.	6.62E+08	268.0946	1577.	0.00
11.1000	0.6698	-185821.	3354.	-0.01371	2561.	6.53E+08	274.4032	1496.	0.00
11.2500	0.6447	-178425.	3854.	-0.01421	2501.	6.45E+08	280.5969	1422.	0.00
11.4000	0.6187	-170087.	4364.	-0.01470	2429.	6.37E+08	286.6738	1353.	0.00
11.5500	0.5918	-160789.	5198.	-0.01517	2345.	6.29E+08	293.8700	1282.	0.00
11.7000	0.5641	-149388.	6257.	-0.01562	2234.	6.21E+08	301.1929	1219.	0.00
11.8500	0.5356	-136221.	7120.	-0.01603	2100.	6.13E+08	308.6335	1164.	0.00
12.0000	0.5063	-121659.	7770.	-0.01641	1947.	6.05E+08	316.0660	1119.	0.00
12.1500	0.4765	-106098.	8196.	-0.01676	1779.	5.97E+08	323.5000	1082.	0.00
12.3000	0.4460	-89960.	8387.	-0.01705	1601.	5.89E+08	330.9348	1045.	0.00
12.4500	0.4151	-73674.	8338.	-0.01730	1417.	5.82E+08	338.3700	1008.	0.00
12.6000	0.3837	-57676.	8052.	-0.01751	1233.	5.74E+08	345.8052	971.	0.00
12.7500	0.3521	-42395.	7533.	-0.01767	1054.	5.66E+08	353.2404	934.	0.00
12.9000	0.3201	-28244.	6794.	-0.01778	885.1957	5.59E+08	360.6756	897.	0.00
13.0500	0.2880	-15609.	5751.	-0.01785	732.4514	5.52E+08	368.1108	860.	0.00
13.2000	0.2559	-5205.	4529.	-0.01788	605.0699	5.44E+08	375.5460	823.	0.00
13.3500	0.2237	3038.	3349.	-0.01789	581.3928	5.37E+08	382.9812	786.	0.00
13.5000	0.1915	9194.	2214.	-0.01787	665.7101	5.30E+08	390.4164	749.	0.00
13.6500	0.1593	13346.	1128.	-0.01783	725.3137	5.23E+08	397.8516	712.	0.00
13.8000	0.1273	15589.	98.9589	-0.01778	760.6767	5.16E+08	405.2868	675.	0.00
13.9500	0.09533	16030.	-864.0019	-0.01772	772.4959	5.09E+08	412.7220	638.	0.00
14.1000	0.06348	14799.	-1745.	-0.01767	761.7965	5.02E+08	420.1572	601.	0.00
14.2500	0.03173	12061.	-2513.	-0.01762	730.1485	4.95E+08	427.5924	564.	0.00
14.4000	5.37E-05	8059.	-2892.	-0.01758	680.2751	4.88E+08	435.0276	527.	0.00
14.5500	-0.03157	3952.	-2572.	-0.01756	627.8474	4.82E+08	442.4628	490.	0.00
14.7000	-0.06316	1097.	-1811.	-0.01755	591.9931	4.75E+08	450.0000	453.	0.00
14.8500	-0.09475	-271.5328	-943.0108	-0.01755	584.3550	4.68E+08	457.4352	416.	0.00
15.0000	-0.1263	0.00	0.00	-0.01755	584.5232	4.62E+08	464.8704	379.	0.00

\* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

Pile-head deflection = 0.99544912 inches  
 Computed slope at pile head = 0.00064964 radians  
 Maximum bending moment = -213500. inch-lbs  
 Maximum shear force = 8387. lbs  
 Depth of maximum bending moment = 9.90000000 feet below pile head  
 Depth of maximum shear force = 12.30000000 feet below pile head  
 Number of iterations = 17  
 Number of zero deflection points = 1

-----  
 Summary of Pile-head Responses for Conventional Analyses  
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Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs  
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians  
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.  
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs  
 Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	36364.	0.9954	6.50E-04	8387.	-213500.

Maximum pile-head deflection = 0.9954491193 inches  
 Maximum pile-head rotation = 0.0006496412 radians = 0.037222 deg.

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 Summary of Warning Messages  
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The following warning was reported 170 times

\*\*\*\* Warning \*\*\*\*

The input value for friction angle is either smaller than 29 degrees or higher than 41 degrees and no value of k has been specified for a soil layer defined using the API sand criteria. Program will assume an internal default value, for k, but the friction angle is outside the range of data available. Please check your input data for correctness.

The analysis ended normally.