

ORDINE DEGLI INGEGNERI
DELLA PROV. DI TRENTO
dott.ing. **ROBERTO BOSETTI**
INSCRIZIONE ALBO N° 1027

IL RESPONSABILE DEL PROCEDIMENTO
dott. ing. Roberto Bosetti

autostrada del brennero

PROGETTO DEFINITIVO PER LA REALIZZAZIONE
DELLA TERZA CORSIA NEL TRATTO COMPRESO
TRA VERONA NORD (KM 223) E L'INTERSEZIONE
CON L'AUTOSTRADA A1 (KM 314)

1	ELABORATI GENERALI
3.1.4.	STUDI SISMICI Regione Veneto Allegato - verifiche a liquefazione

0	MAR. 2021	EMISSIONE	M. ZINI	M. TAMANINI	C. COSTA
REVISIONE:	DATA:	DESCRIZIONE:	REDAZIONE:	VERIFICA:	APPROVAZIONE:
DATA PROGETTO: LUGLIO 2009		DIREZIONE TECNICA GENERALE	IL DIRETTORE TECNICO GENERALE E PROGETTISTA:		
NUMERO PROGETTO: 31/09			 <p>ORDINE DEGLI INGEGNERI DELLA PROV. DI BOLZANO Dott. ing. CARLO COSTA Nr. 891 INGENIEURKAMMER DER PROVINZ BOZEN</p>		



**Autostrada del Brennero SpA
Brennerautobahn AG**

**Realizzazione della terza corsia
nel tratto compreso tra Verona nord (km 223)
e l'intersezione con l'autostrada A1 (km 314)
PROGETTO ESECUTIVO**

**Studio sismico, con verifica a liquefazione e risposta
sismica locale, relativo alle opere minori**

Tratto Regione Veneto

**ALLEGATO
VERIFICHE A LIQUEFAZIONE**

STUDIO SISMICO

Elaborato:

VEN-SI.4

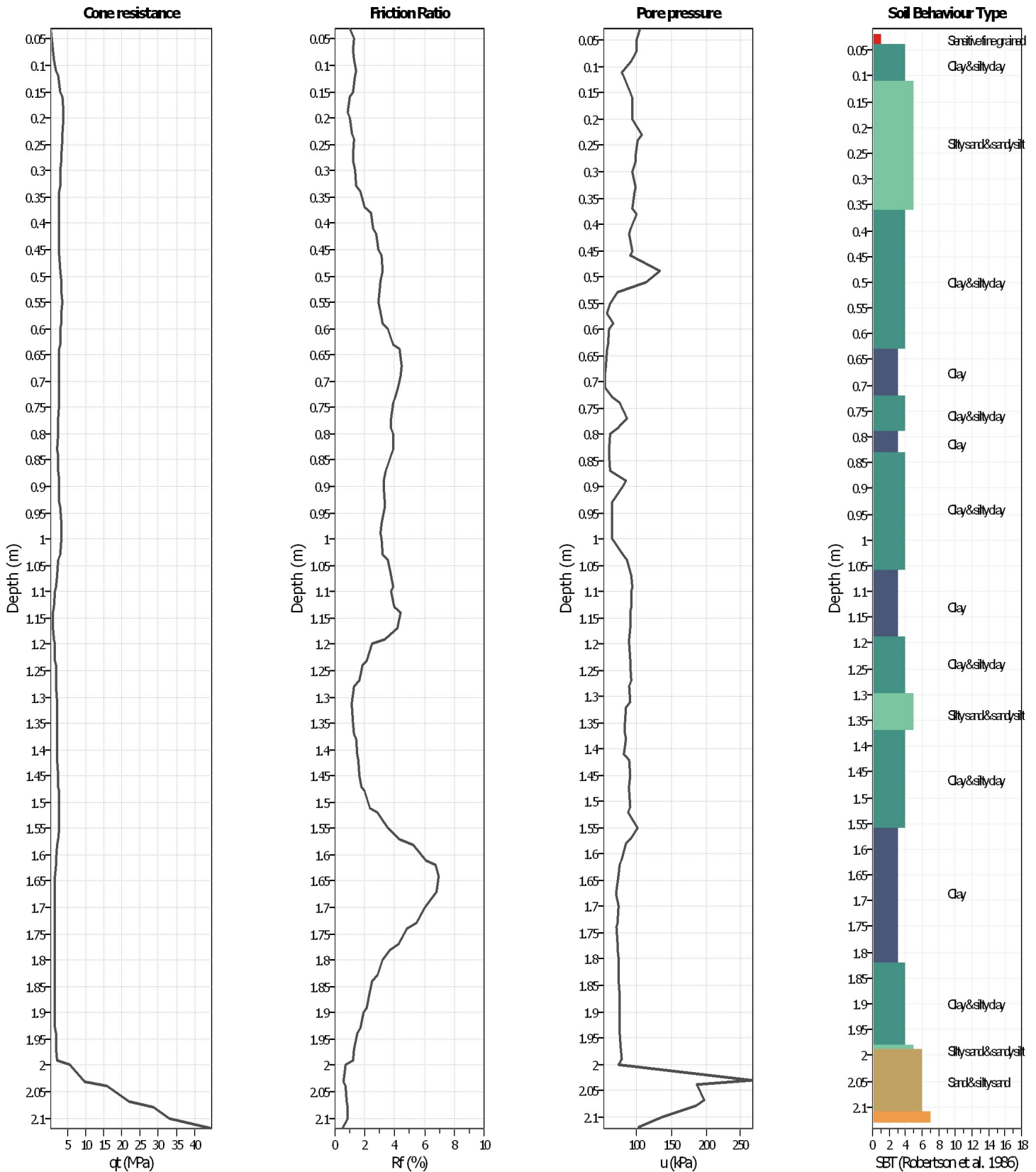
Il tecnico incaricato:

Dott. Geol. Alessandro Ferrari

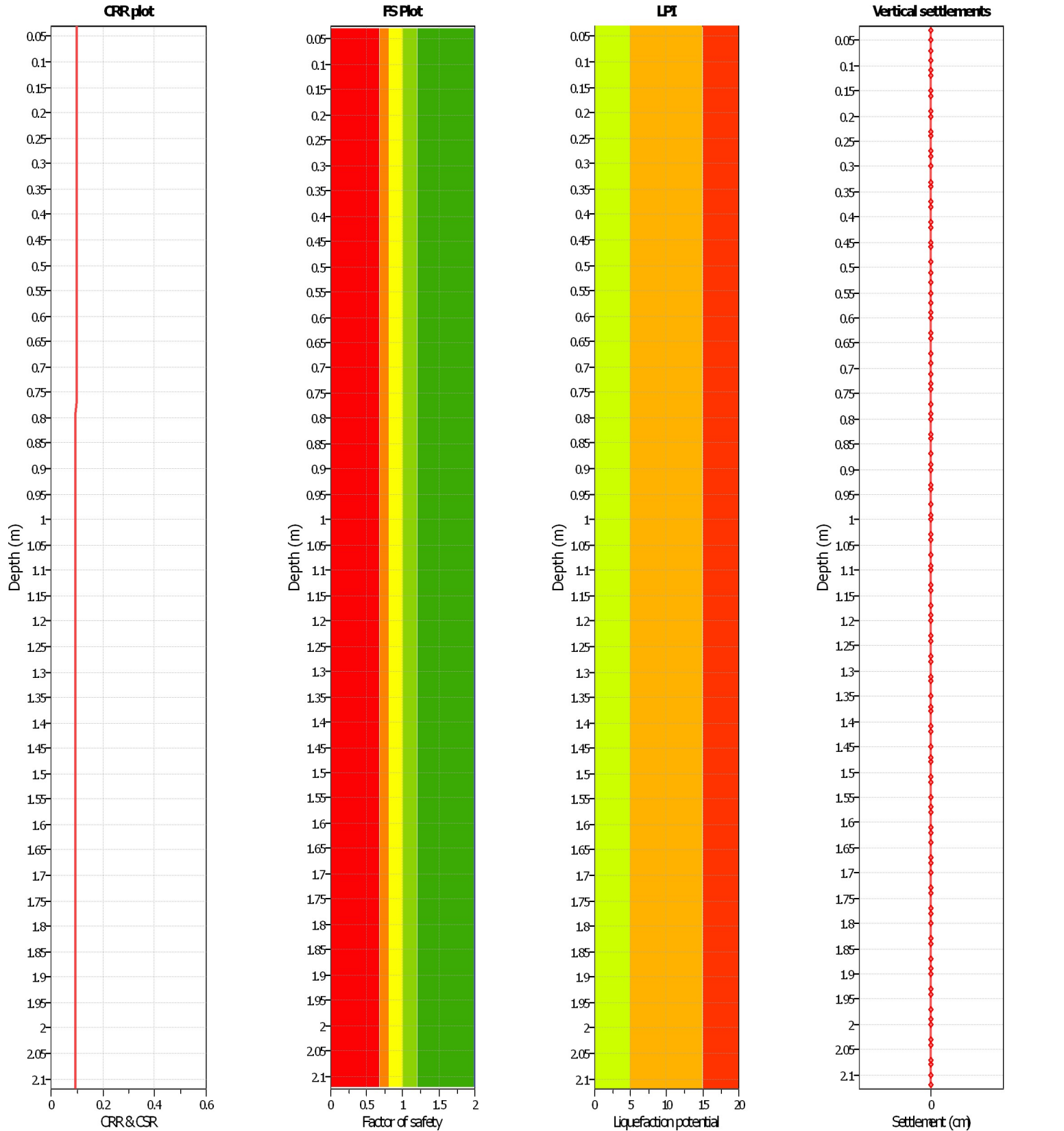


Iscritto all'Ordine dei Geologi dell'Emilia Romagna n° 1323
Sede legale : Viale Partigiani d'Italia, 18 - 43123 Parma
Partita IVA:02606040349
Tel. 349 3510561
ferrari.geologia@gmail.com
www.ferrariologia.it

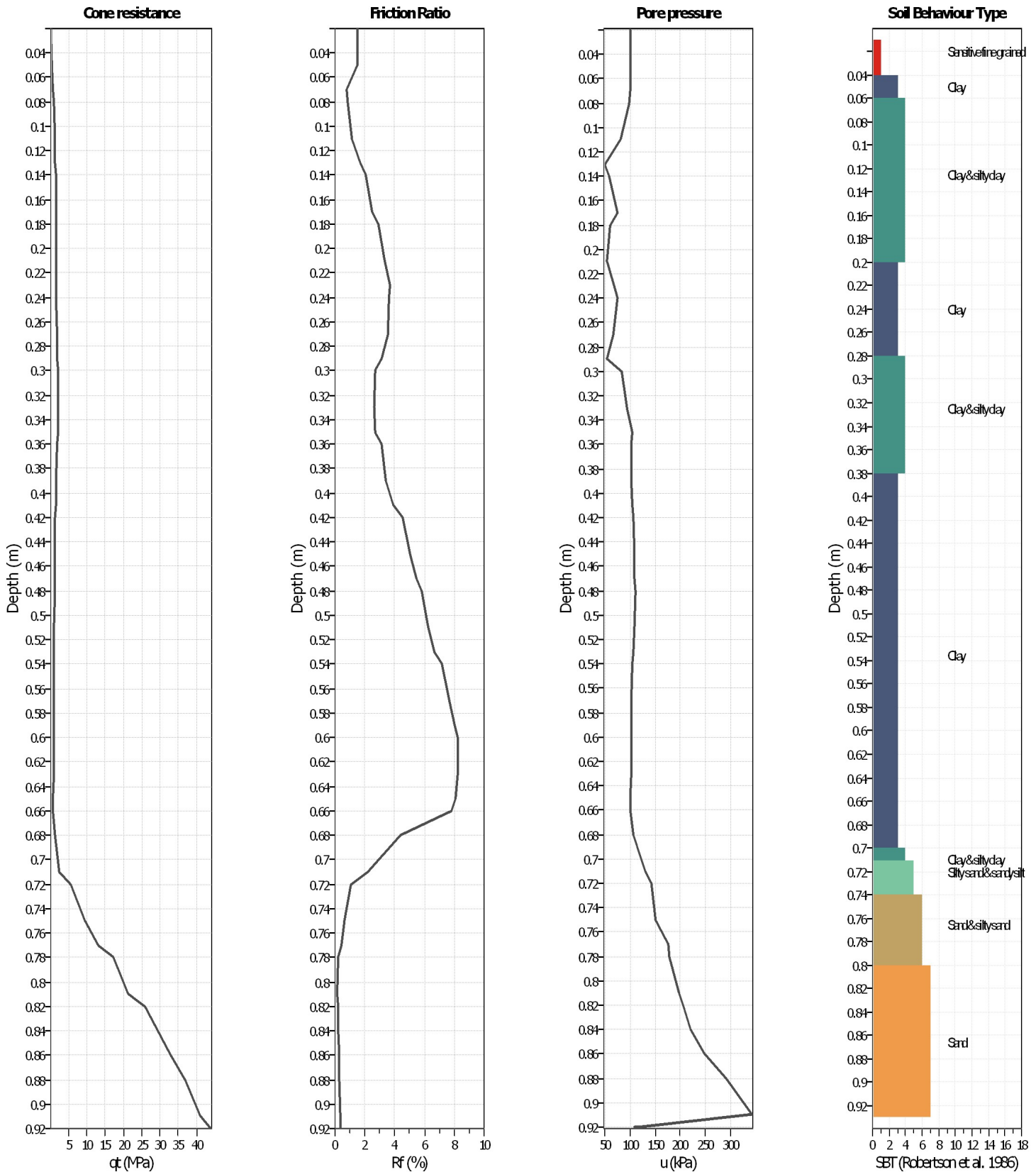
**APRILE
2017**



Analysis method:	NCEER (1998)	G.W.T. (in-situ):	3.40 m	Use fill:	No	Clay like behavior applied:	Yes
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	11.00 m	Fill height:	N/A	Sands only:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	20.00 m
Earthquake magnitude M_w :	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_0 applied:	Yes		

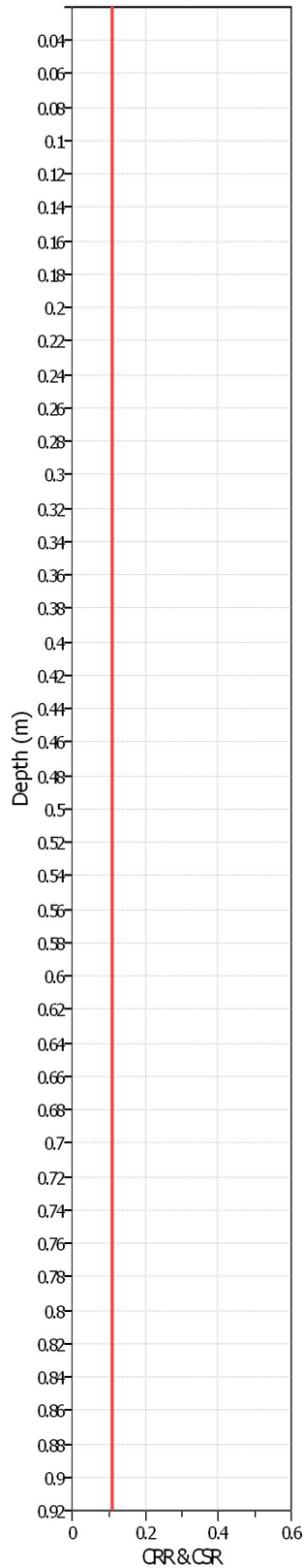


Analysis method:	NCEER (1998)	G.W.T. (in-situ):	3.40 m	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	11.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w :	5.90	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_0 applied:	Yes		

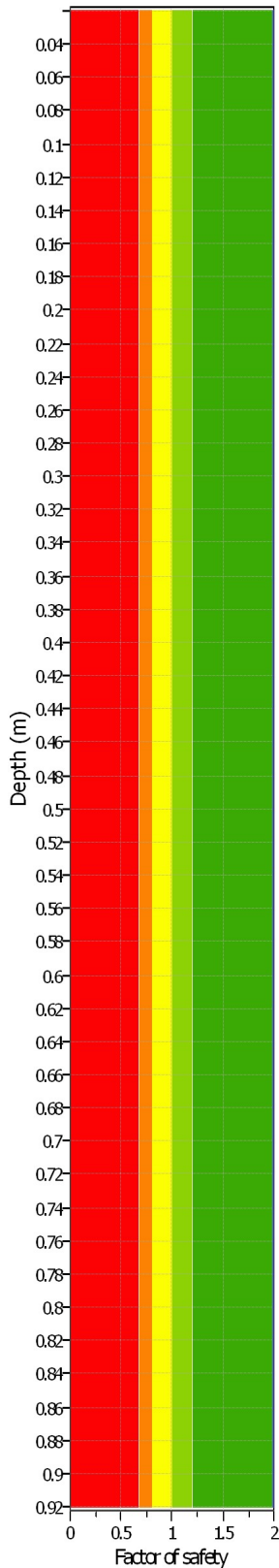


Analysis method:	NCEER (1998)	G.W.T. (in-situ):	3.40 m	Use fill:	No	Clay like behavior	
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.80 m	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	20.00 m
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:	Method based

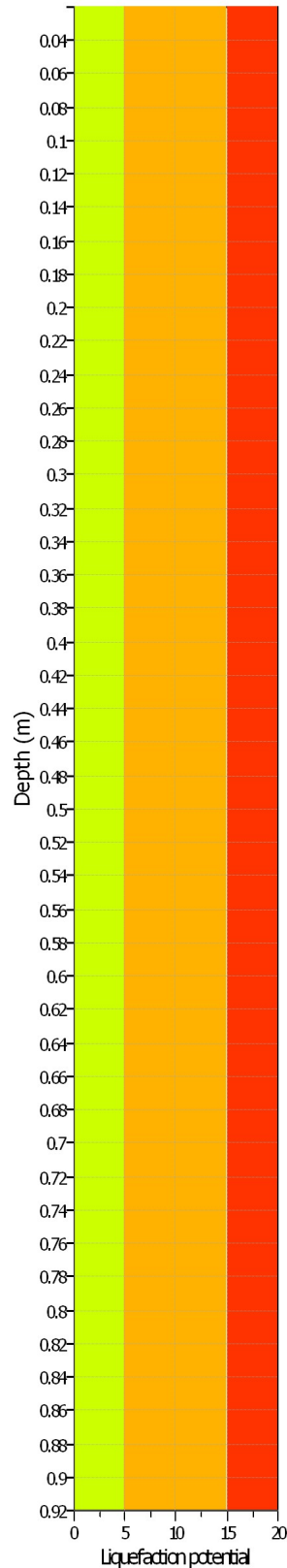
CRR plot



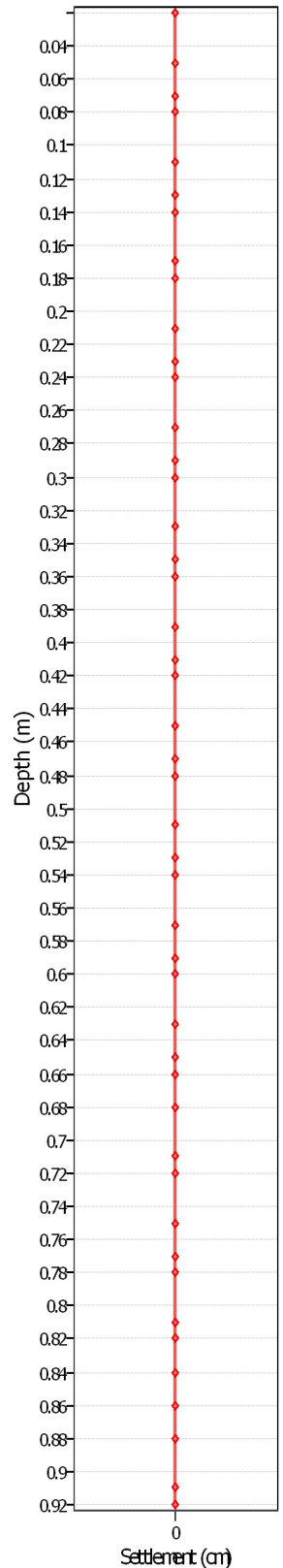
FS Plot



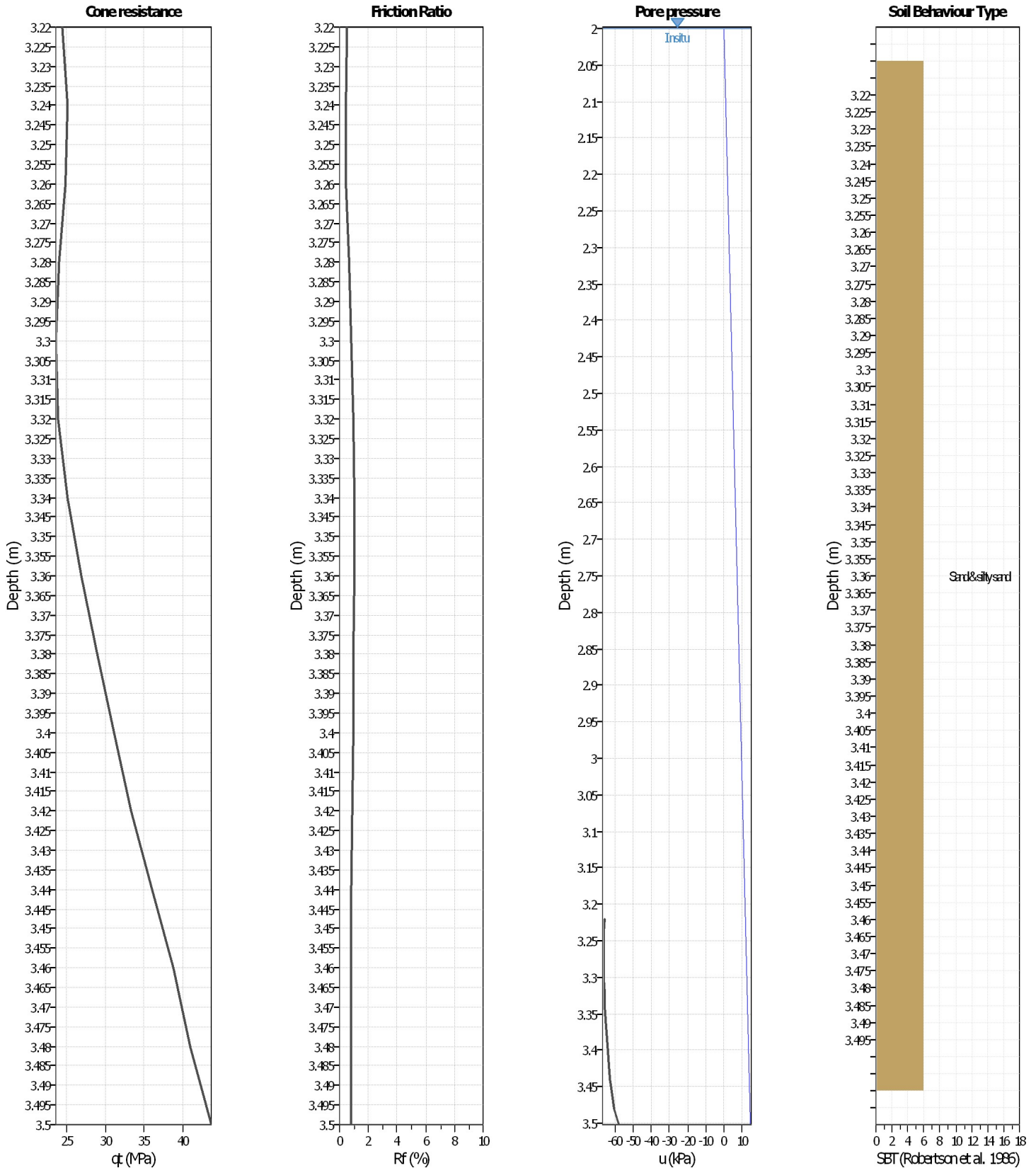
LPI



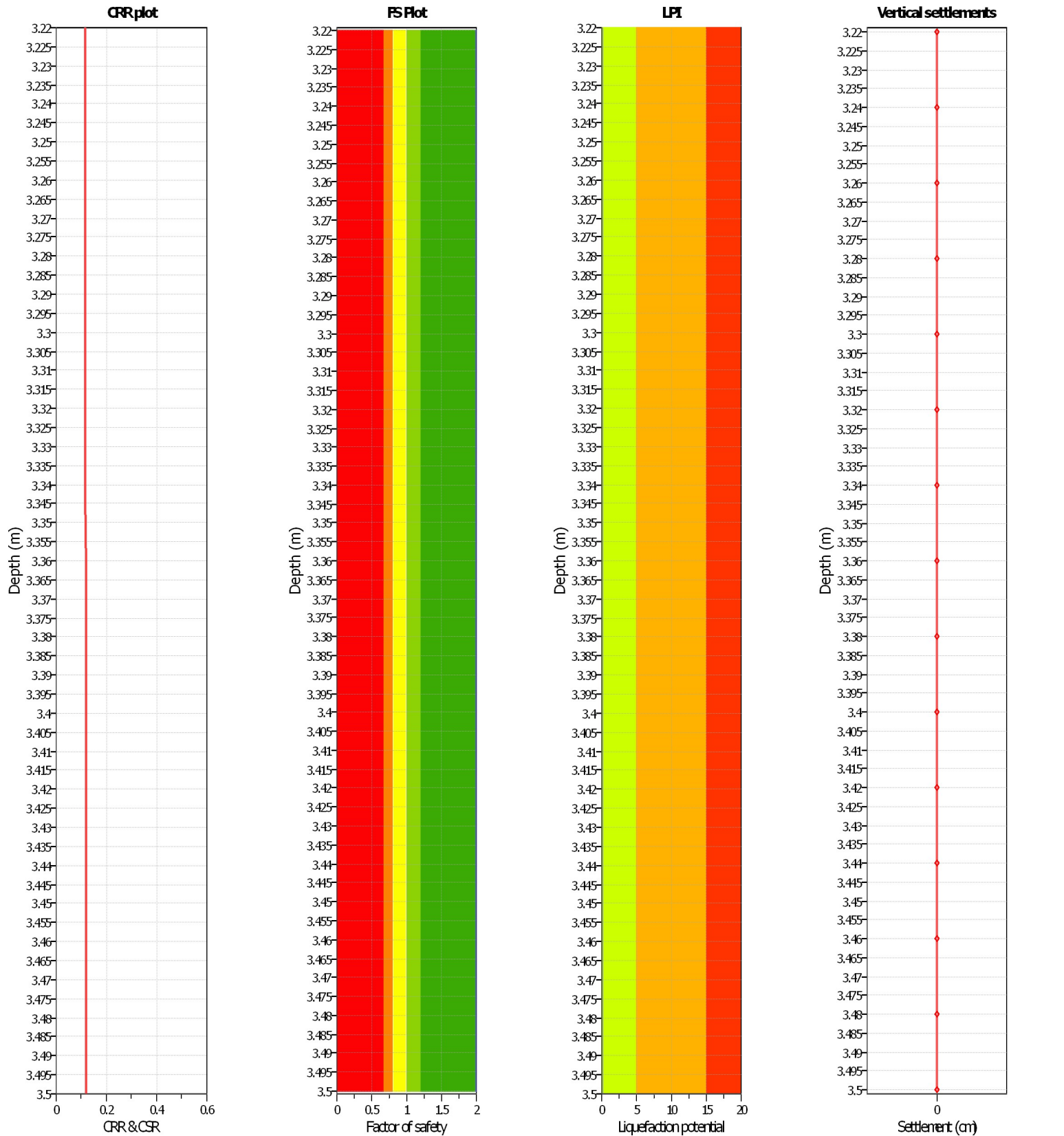
Vertical settlements



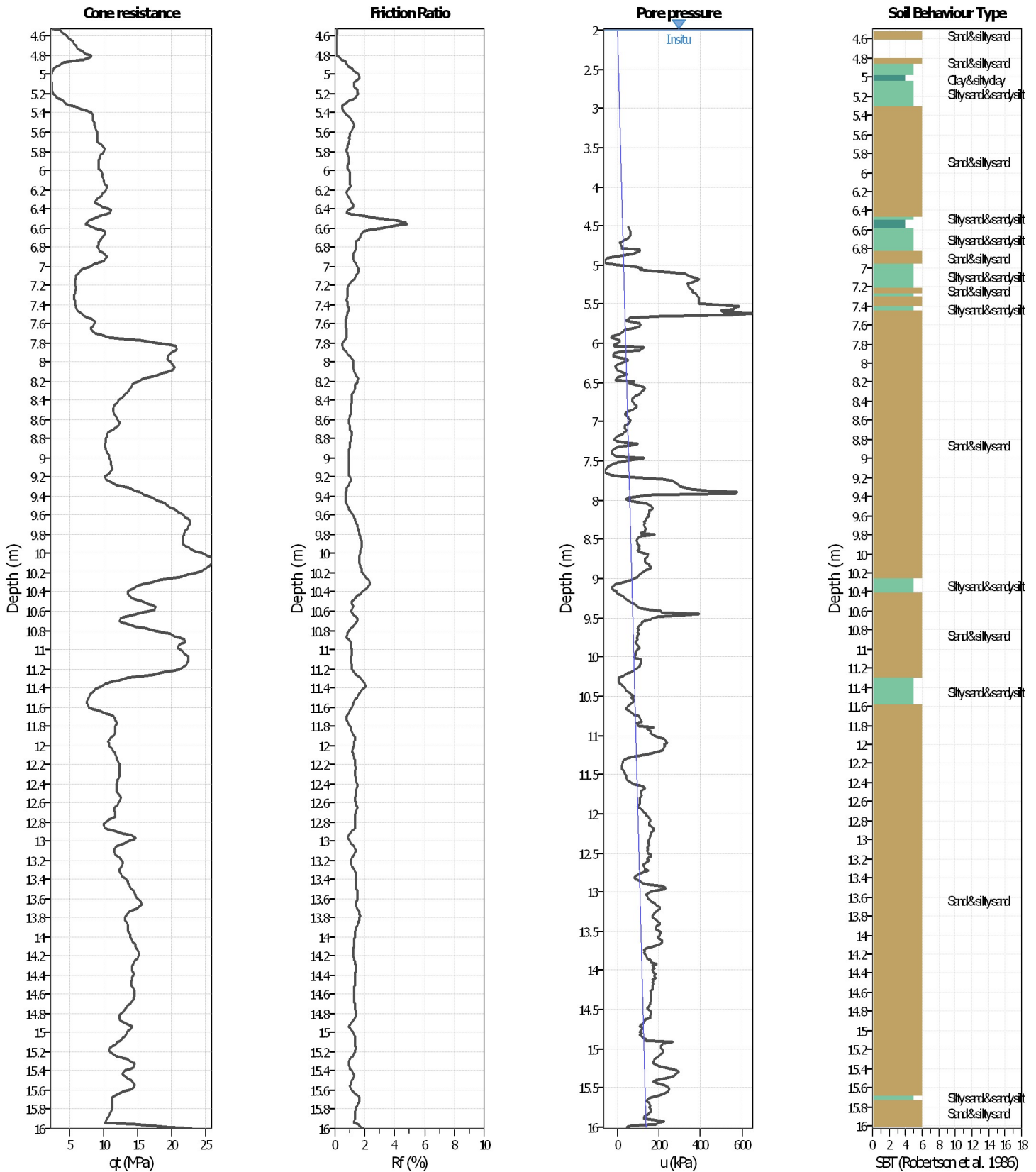
Analysis method:	NCEER (1998)	G.W.T. (in-situ):	3.40 m	Use fill:	No	Clay like behavior	
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.80 m	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	20.00 m
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:	Method based



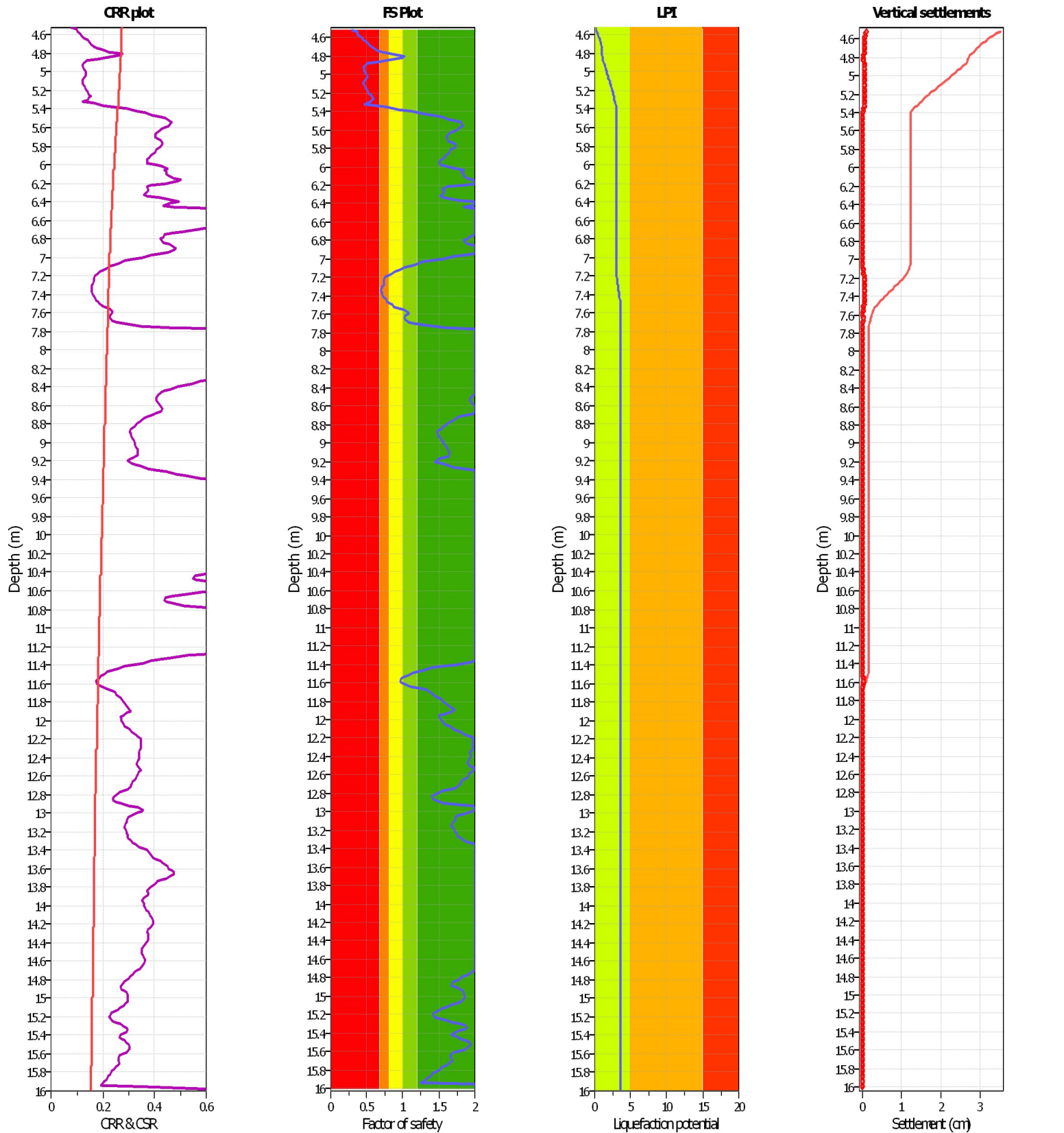
Analysis method:	NCEER (1998)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior	
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.80 m	Fill height:	N/A	applied:	Sands only
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w :	6.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	20.00 m
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:	Method based



Analysis method:	NCEER (1998)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior	
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	1.80 m	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:	Yes
Earthquake magnitude M_w :	6.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	20.00 m
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:	Method based



Analysis method:	NCEER (1998)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior	
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	0.20 m	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:	Yes
Earthquake magnitude M_w :	6.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	20.00 m
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:	Method based



Analysis method:	NCEER (1998)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior	
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	0.20 m	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:	Yes
Earthquake magnitude M_w :	6.00	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	Limit depth:	20.00 m
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_0 applied:	Yes	MSF method:	Method based

LIQUEFACTION ANALYSIS REPORT

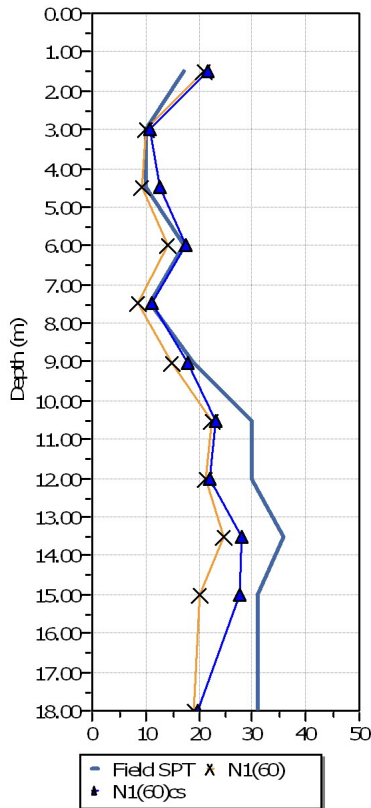
Project title : Verifiche liquefazione - Regione Veneto

Project subtitle : VR-SC27

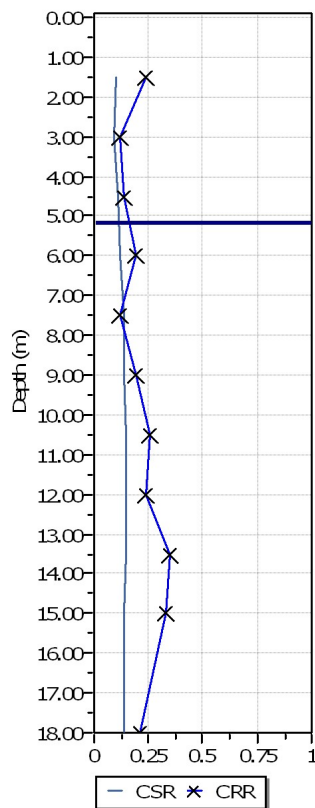
Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	5.20 m
Analysis type:	Deterministic	Earthquake magnitude M_w :	5.90
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.20

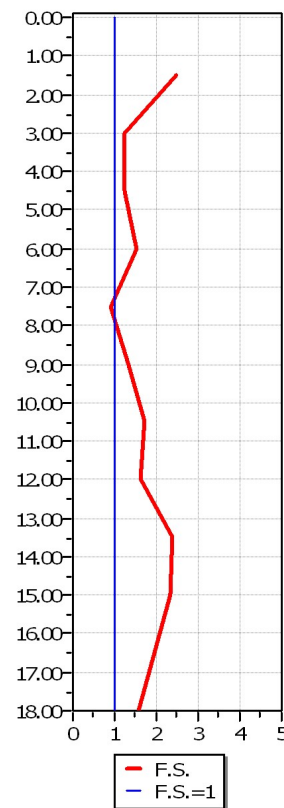
SPT data graph



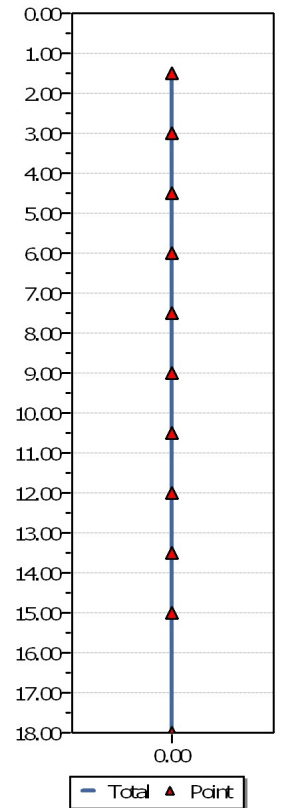
Shear stress ratio



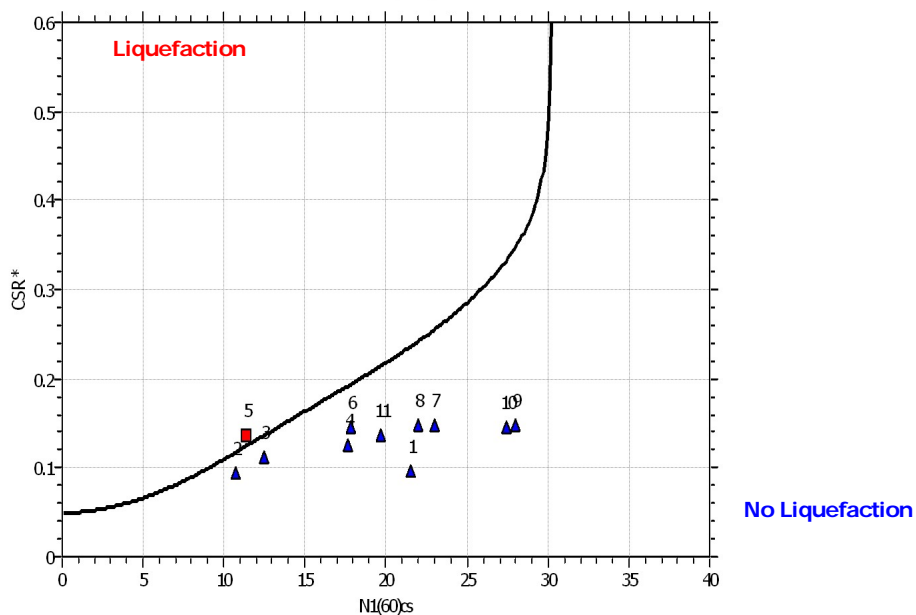
Factor of safety



Settlements (cm)



$M_w=7^{1/2}$, $\sigma'_v=1$ atm base curve



:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (m)	Sigma (kPa)	u (kPa)	Sigma' (kPa)	r _d	CSR	MSF	CSR _{eq,M=7.5}	K _{sigma}	CSR*
1	1.50	28.50	0.00	28.50	0.99	0.15	1.85	0.08	1.00	0.08
2	3.00	57.00	0.00	57.00	0.98	0.15	1.85	0.08	1.00	0.08
3	4.50	85.50	13.73	71.77	0.97	0.17	1.85	0.09	1.00	0.09
4	6.00	114.00	28.45	85.55	0.95	0.19	1.85	0.10	0.99	0.10
5	7.50	142.50	43.16	99.34	0.94	0.20	1.85	0.11	0.96	0.11
6	9.00	171.00	57.88	113.12	0.93	0.21	1.85	0.11	0.94	0.12
7	10.50	199.50	72.59	126.91	0.89	0.21	1.85	0.11	0.93	0.12
8	12.00	228.00	87.31	140.69	0.85	0.21	1.85	0.11	0.91	0.12
9	13.50	256.50	102.02	154.48	0.81	0.20	1.85	0.11	0.89	0.12
10	15.00	285.00	116.74	168.26	0.77	0.20	1.85	0.11	0.88	0.12
11	18.00	342.00	146.17	195.83	0.69	0.18	1.85	0.10	0.86	0.11

Depth : Depth from free surface, at which SPT was performed (m)
 Sigma : Total overburden pressure at test point, during earthquake (kPa)
 u : Water pressure at test point, during earthquake (kPa)
 Sigma' : Effective overburden pressure, during earthquake (kPa)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 CSR_{eq,M=7.5} : CSR adjusted for M= 7.5
 K_{sigma} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation CRR_{7.5} ::

Point ID	Field SPT	C _n	C _e	C _b	C _r	C _s	N ₁₍₆₀₎	DeltaN	N _{1(60)cs}	CRR _{7.5}
1	17.00	1.70	0.90	1.00	0.80	1.00	20.81	0.76	21.57	0.24
2	10.00	1.32	0.90	1.00	0.85	1.00	10.13	0.60	10.73	0.12
3	10.00	1.08	0.90	1.00	0.95	1.00	9.25	3.27	12.51	0.14
4	17.00	0.97	0.90	1.00	0.95	1.00	14.11	3.53	17.64	0.19
5	11.00	0.91	0.90	1.00	0.95	1.00	8.59	2.74	11.33	0.12
6	19.00	0.86	0.90	1.00	1.00	1.00	14.79	3.02	17.81	0.19
7	30.00	0.82	0.90	1.00	1.00	1.00	22.23	0.78	23.01	0.26
8	30.00	0.79	0.90	1.00	1.00	1.00	21.26	0.77	22.03	0.24
9	36.00	0.76	0.90	1.00	1.00	1.00	24.49	3.46	27.95	0.35
10	31.00	0.73	0.90	1.00	1.00	1.00	20.30	7.17	27.47	0.33
11	31.00	0.68	0.90	1.00	1.00	1.00	18.96	0.73	19.70	0.21

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Liner correction factor
 N₁₍₆₀₎ : Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 N_{1(60)cs} : Corrected N₁₍₆₀₎ value for fines
 CRR_{7.5} : Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	N ₁₍₆₀₎	N ₁	FSL	e _v (%)	Settle. (cm)
1	21.57	17.97	2.46	0.00	0.00
2	10.73	8.94	1.24	0.39	0.00
3	12.51	10.43	1.22	0.39	0.00
4	17.64	14.70	1.53	0.08	0.00
5	11.33	9.44	0.91	3.51	0.00
6	17.81	14.84	1.34	0.18	0.00
7	23.01	19.18	1.73	0.03	0.00
8	22.03	18.36	1.64	0.05	0.00
9	27.95	23.29	2.36	0.00	0.00
10	27.47	22.90	2.31	0.00	0.00

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (cm)
11	19.70	16.42	1.56	0.07	0.00

Total settlement : 0.00

$N_{1(60)}$: Stress normalized and corrected SPT blow count
 N_1 : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle.: Calculated settlement (cm)

:: Liquefaction potential according to I wasaki ::

Point ID	F	w_z	I_L
1	0.00	9.25	0.00
2	0.00	8.50	0.00
3	0.00	7.75	0.00
4	0.00	7.00	0.00
5	0.09	6.25	0.85
6	0.00	5.50	0.00
7	0.00	4.75	0.00
8	0.00	4.00	0.00
9	0.00	3.25	0.00
10	0.00	2.50	0.00
11	0.00	1.00	0.00

Overall potential I_L : 0.85

$I_L = 0.00$ - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 $I_L > 15$ - Liquefaction certain

LIQUEFACTION ANALYSIS REPORT

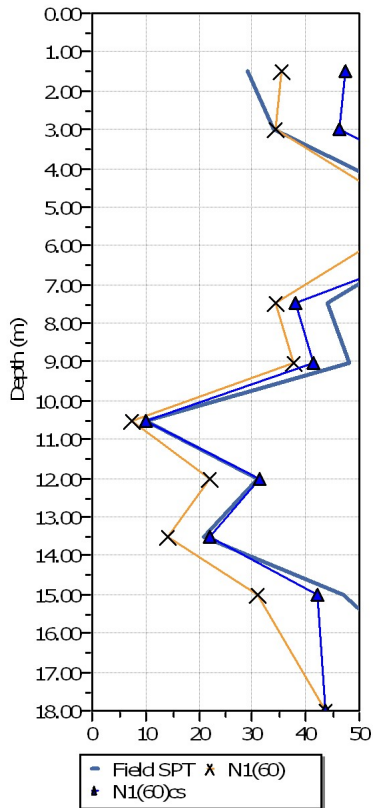
Project title : Verifiche liquefazione - Regione Veneto

Project subtitle : VR-SC30

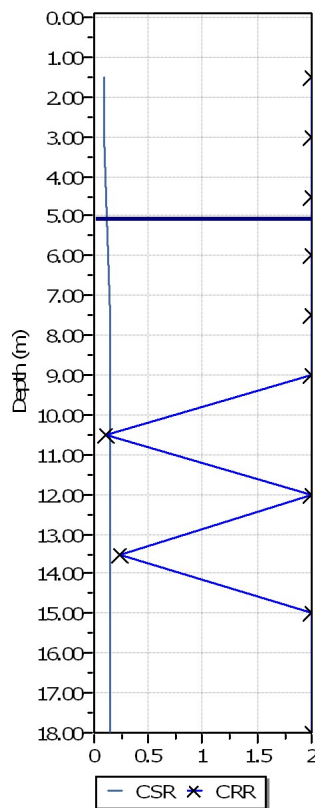
Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	5.10 m
Analysis type:	Deterministic	Earthquake magnitude M_w :	5.90
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.20

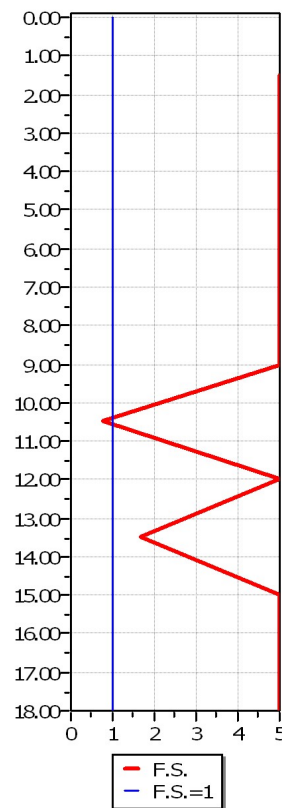
SPT data graph



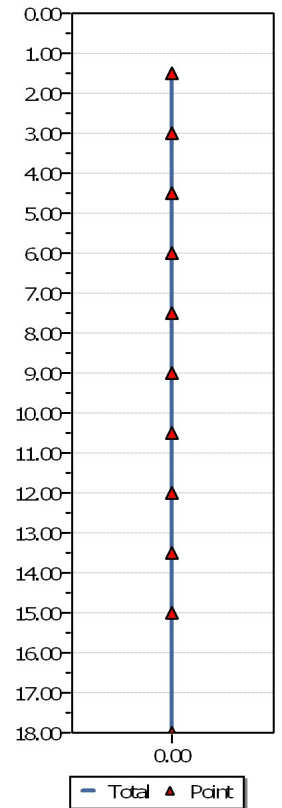
Shear stress ratio



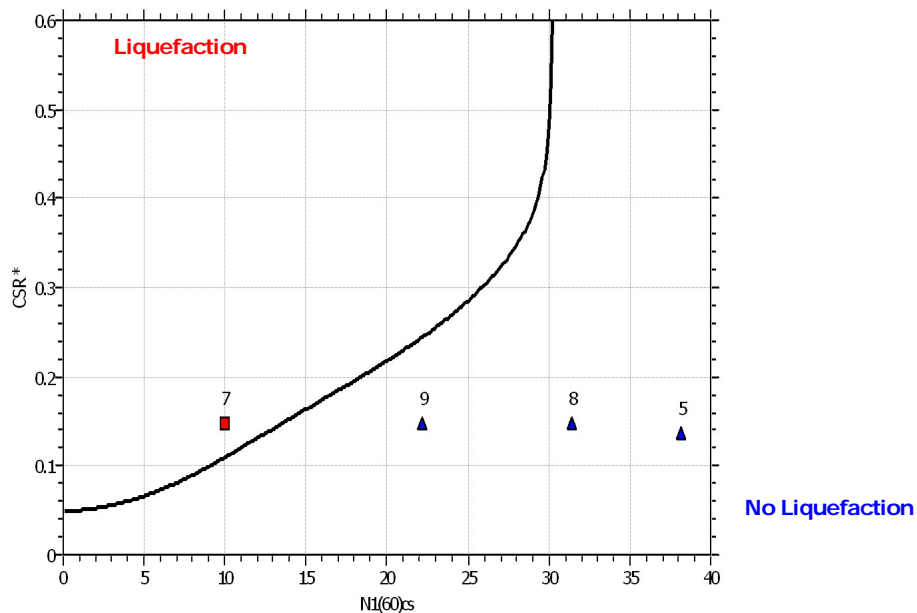
Factor of safety



Settlements (cm)



$M_w=7^{1/2}$, $\sigma'_v=1$ atm base curve



:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (m)	Sigma (kPa)	u (kPa)	Sigma' (kPa)	r _d	CSR	MSF	CSR _{eq,M=7.5}	K _{sigma}	CSR*
1	1.50	28.50	0.00	28.50	0.99	0.15	1.85	0.08	1.00	0.08
2	3.00	57.00	0.00	57.00	0.98	0.15	1.85	0.08	1.00	0.08
3	4.50	85.50	13.73	71.77	0.97	0.17	1.85	0.09	1.00	0.09
4	6.00	114.00	28.45	85.55	0.95	0.19	1.85	0.10	0.99	0.10
5	7.50	142.50	43.16	99.34	0.94	0.20	1.85	0.11	0.97	0.11
6	9.00	171.00	57.88	113.12	0.93	0.21	1.85	0.11	0.94	0.12
7	10.50	199.50	72.59	126.91	0.89	0.21	1.85	0.11	0.93	0.12
8	12.00	228.00	87.31	140.69	0.85	0.21	1.85	0.11	0.91	0.12
9	13.50	256.50	102.02	154.48	0.81	0.20	1.85	0.11	0.90	0.12
10	15.00	285.00	116.74	168.26	0.77	0.20	1.85	0.11	0.88	0.12
11	18.00	342.00	146.17	195.83	0.69	0.18	1.85	0.10	0.86	0.11

Depth : Depth from free surface, at which SPT was performed (m)
 Sigma : Total overburden pressure at test point, during earthquake (kPa)
 u : Water pressure at test point, during earthquake (kPa)
 Sigma' : Effective overburden pressure, during earthquake (kPa)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 CSR_{eq,M=7.5} : CSR adjusted for M= 7.5
 K_{sigma} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation CRR_{7.5} ::

Point ID	Field SPT	C _n	C _e	C _b	C _r	C _s	N ₁₍₆₀₎	DeltaN	N _{1(60)cs}	CRR _{7.5}
1	29.00	1.70	0.90	1.00	0.80	1.00	35.50	11.97	47.47	2.00
2	34.00	1.32	0.90	1.00	0.85	1.00	34.45	11.89	46.34	2.00
3	56.00	1.08	0.90	1.00	0.95	1.00	51.78	15.18	66.96	2.00
4	62.00	0.98	0.90	1.00	0.95	1.00	51.69	15.16	66.85	2.00
5	44.00	0.92	0.90	1.00	0.95	1.00	34.49	3.67	38.16	2.00
6	48.00	0.87	0.90	1.00	1.00	1.00	37.50	3.79	41.29	2.00
7	10.00	0.83	0.90	1.00	1.00	1.00	7.44	2.52	9.95	0.11
8	31.00	0.79	0.90	1.00	1.00	1.00	22.04	9.41	31.44	2.00
9	21.00	0.76	0.90	1.00	1.00	1.00	14.32	7.86	22.19	0.24
10	47.00	0.73	0.90	1.00	1.00	1.00	30.86	11.17	42.03	2.00
11	71.00	0.68	0.90	1.00	1.00	1.00	43.53	0.23	43.77	2.00

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Liner correction factor
 N₁₍₆₀₎ : Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 N_{1(60)cs} : Corrected N₁₍₆₀₎ value for fines
 CRR_{7.5} : Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	N ₁₍₆₀₎	N ₁	FSL	e _v (%)	Settle. (cm)
1	47.47	39.56	5.00	0.00	0.00
2	46.34	38.62	5.00	0.00	0.00
3	66.96	55.80	5.00	0.00	0.00
4	66.85	55.71	5.00	0.00	0.00
5	38.16	31.80	5.00	0.00	0.00
6	41.29	34.41	5.00	0.00	0.00
7	9.95	8.30	0.74	3.88	0.00
8	31.44	26.20	5.00	0.00	0.00
9	22.19	18.49	1.66	0.04	0.00
10	42.03	35.03	5.00	0.00	0.00

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (cm)
11	43.77	36.47	5.00	0.00	0.00

Total settlement : 0.00

$N_{1(60)}$: Stress normalized and corrected SPT blow count
 N_1 : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle.: Calculated settlement (cm)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w_z	I_L
1	0.00	9.25	0.00
2	0.00	8.50	0.00
3	0.00	7.75	0.00
4	0.00	7.00	0.00
5	0.00	6.25	0.00
6	0.00	5.50	0.00
7	0.26	4.75	1.85
8	0.00	4.00	0.00
9	0.00	3.25	0.00
10	0.00	2.50	0.00
11	0.00	1.00	0.00

Overall potential I_L : 1.85

$I_L = 0.00$ - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 $I_L > 15$ - Liquefaction certain

LIQUEFACTION ANALYSIS REPORT

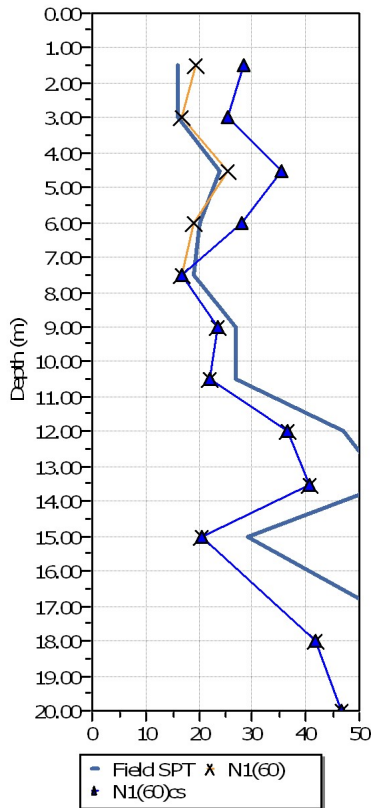
Project title : Verifiche liquefazione - Regione Veneto

Project subtitle : VR-SC34

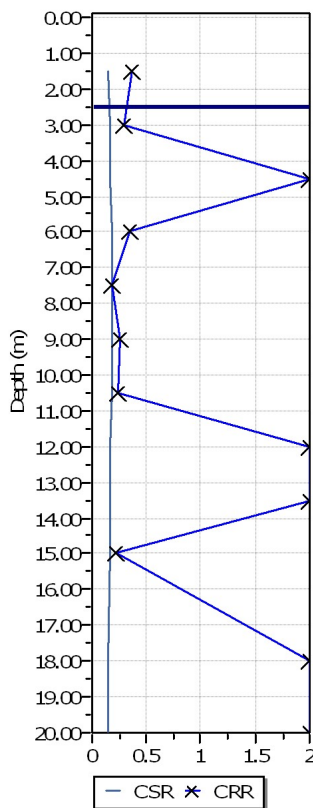
Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	2.50 m
Analysis type:	Deterministic	Earthquake magnitude M_w :	5.90
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.20

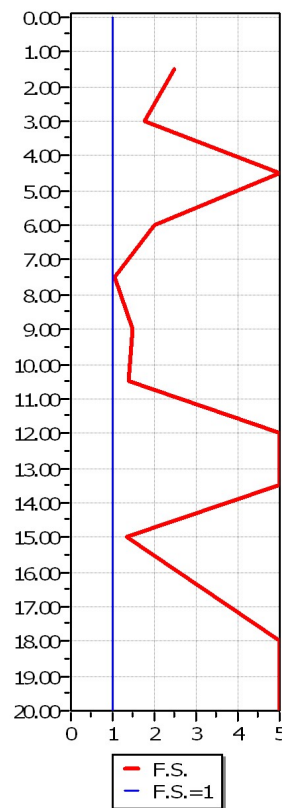
SPT data graph



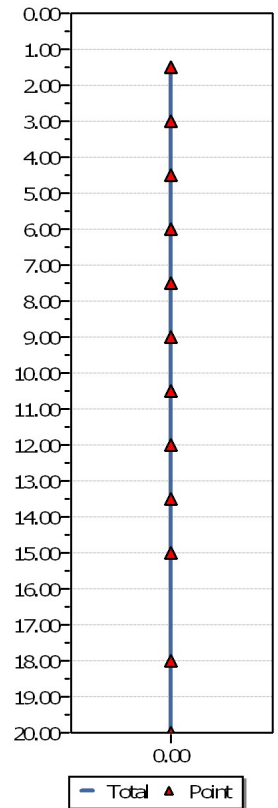
Shear stress ratio



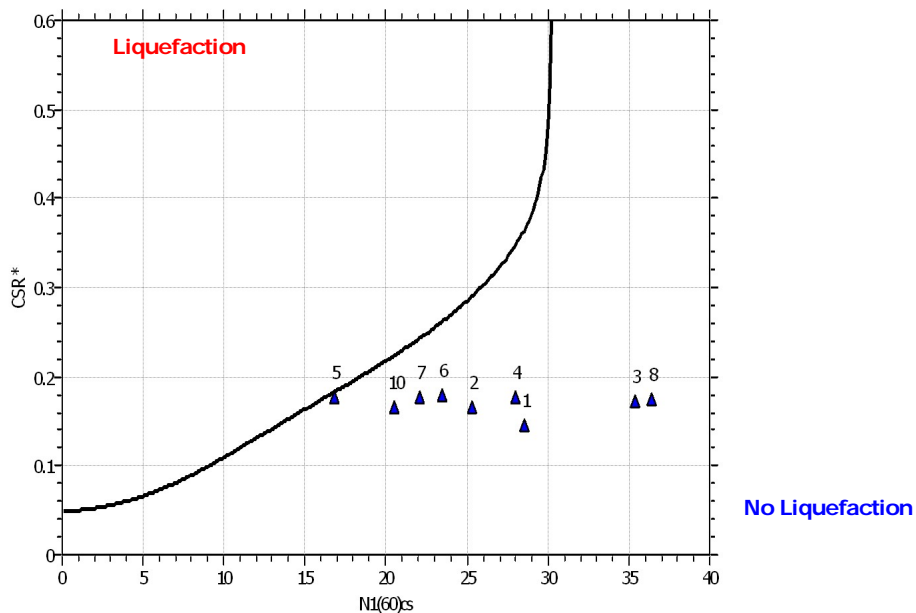
Factor of safety



Settlements (cm)



$M_w=7^{1/2}$, $\sigma'_v=1$ atm base curve



:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (m)	Sigma (kPa)	u (kPa)	Sigma' (kPa)	r _d	CSR	MSF	CSR _{eq,M=7.5}	K _{sigma}	CSR*
1	1.50	28.50	9.81	18.69	0.99	0.23	1.85	0.12	1.00	0.12
2	3.00	57.00	24.52	32.48	0.98	0.26	1.85	0.14	1.00	0.14
3	4.50	85.50	39.24	46.26	0.97	0.27	1.85	0.14	1.00	0.14
4	6.00	114.00	53.95	60.05	0.95	0.27	1.85	0.15	1.00	0.15
5	7.50	142.50	68.67	73.83	0.94	0.27	1.85	0.15	1.00	0.15
6	9.00	171.00	83.39	87.61	0.93	0.27	1.85	0.15	0.99	0.15
7	10.50	199.50	98.10	101.40	0.89	0.26	1.85	0.14	0.96	0.15
8	12.00	228.00	112.81	115.19	0.85	0.25	1.85	0.14	0.94	0.15
9	13.50	256.50	127.53	128.97	0.81	0.24	1.85	0.13	0.92	0.14
10	15.00	285.00	142.25	142.75	0.77	0.23	1.85	0.13	0.91	0.14
11	18.00	342.00	171.68	170.32	0.69	0.21	1.85	0.11	0.88	0.13
12	20.00	380.00	191.29	188.71	0.64	0.19	1.85	0.10	0.86	0.12

Depth : Depth from free surface, at which SPT was performed (m)
 Sigma : Total overburden pressure at test point, during earthquake (kPa)
 u : Water pressure at test point, during earthquake (kPa)
 Sigma' : Effective overburden pressure, during earthquake (kPa)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 CSR_{eq,M=7.5} : CSR adjusted for M= 7.5
 K_{sigma} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation CRR_{7.5} ::

Point ID	Field SPT	C _n	C _e	C _b	C _r	C _s	N ₁₍₆₀₎	DeltaN	N _{1(60)cs}	CRR _{7.5}
1	16.00	1.70	0.90	1.00	0.80	1.00	19.58	8.92	28.50	0.36
2	16.00	1.39	0.90	1.00	0.85	1.00	16.96	8.39	25.35	0.29
3	24.00	1.23	0.90	1.00	0.95	1.00	25.28	10.06	35.34	2.00
4	20.00	1.12	0.90	1.00	0.95	1.00	19.16	8.83	27.99	0.35
5	19.00	1.03	0.90	1.00	0.95	1.00	16.80	0.00	16.80	0.18
6	27.00	0.97	0.90	1.00	1.00	1.00	23.47	0.00	23.47	0.26
7	27.00	0.91	0.90	1.00	1.00	1.00	22.09	0.00	22.09	0.24
8	47.00	0.86	0.90	1.00	1.00	1.00	36.43	0.00	36.43	2.00
9	55.00	0.82	0.90	1.00	1.00	1.00	40.61	0.00	40.61	2.00
10	29.00	0.78	0.90	1.00	1.00	1.00	20.48	0.00	20.48	0.22
11	64.00	0.73	0.90	1.00	1.00	1.00	41.79	0.00	41.79	2.00
12	75.00	0.69	0.90	1.00	1.00	1.00	46.77	0.00	46.77	2.00

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Liner correction factor
 N₁₍₆₀₎ : Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 N_{1(60)cs} : Corrected N₁₍₆₀₎ value for fines
 CRR_{7.5} : Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	N ₁₍₆₀₎	N ₁	FS _L	e _v (%)	Settle. (cm)
1	28.50	23.75	2.48	0.00	0.00
2	25.35	21.12	1.75	0.03	0.00
3	35.34	29.45	5.00	0.00	0.00
4	27.99	23.33	1.98	0.00	0.00
5	16.80	14.00	1.03	1.13	0.00
6	23.47	19.55	1.46	0.09	0.00
7	22.09	18.41	1.37	0.13	0.00
8	36.43	30.36	5.00	0.00	0.00

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (cm)
9	40.61	33.84	5.00	0.00	0.00
10	20.48	17.07	1.35	0.15	0.00
11	41.79	34.83	5.00	0.00	0.00
12	46.77	38.97	5.00	0.00	0.00

Total settlement : 0.00

$N_{1(60)}$: Stress normalized and corrected SPT blow count
 N_1 : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle.: Calculated settlement (cm)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w_z	I_L
1	0.00	9.25	0.00
2	0.00	8.50	0.00
3	0.00	7.75	0.00
4	0.00	7.00	0.00
5	0.00	6.25	0.00
6	0.00	5.50	0.00
7	0.00	4.75	0.00
8	0.00	4.00	0.00
9	0.00	3.25	0.00
10	0.00	2.50	0.00
11	0.00	1.00	0.00
12	0.00	0.00	0.00

Overall potential I_L : 0.00

$I_L = 0.00$ - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 $I_L > 15$ - Liquefaction certain

LIQUEFACTION ANALYSIS REPORT

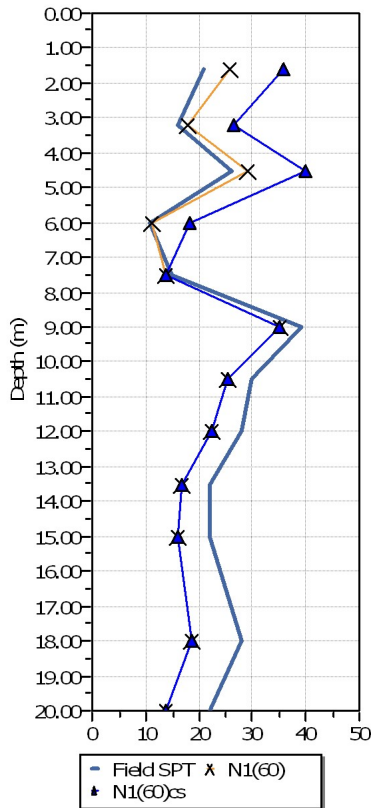
Project title : Verifiche liquefazione - Regione Veneto

Project subtitle : VR-SC36

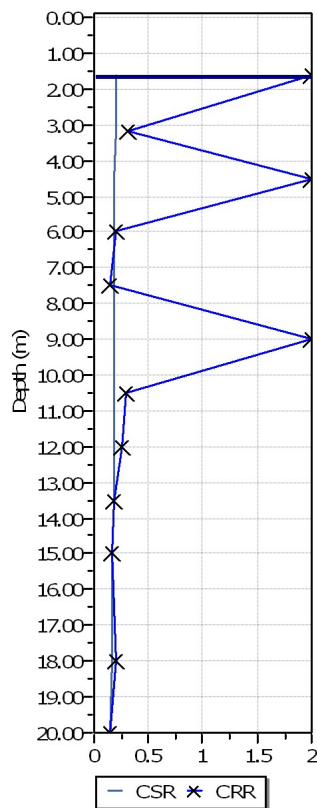
Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	1.70 m
Analysis type:	Deterministic	Earthquake magnitude M_w :	5.90
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.20

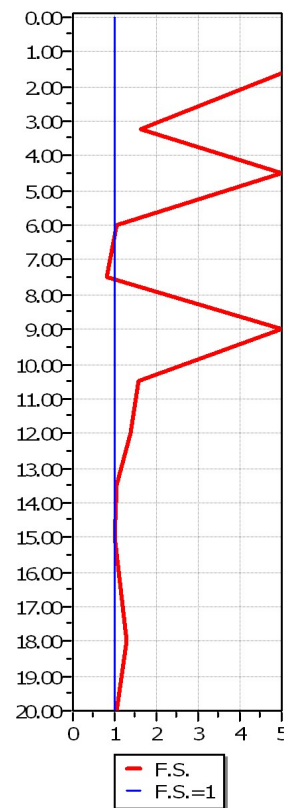
SPT data graph



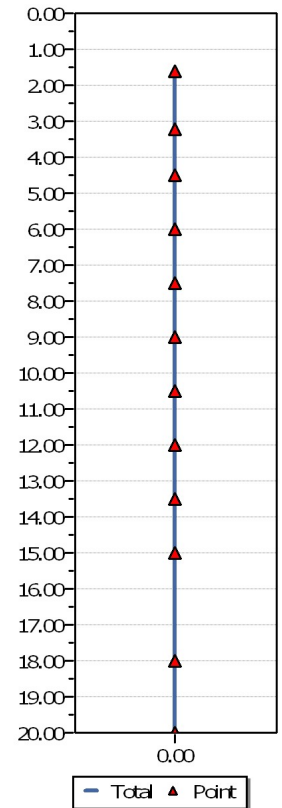
Shear stress ratio



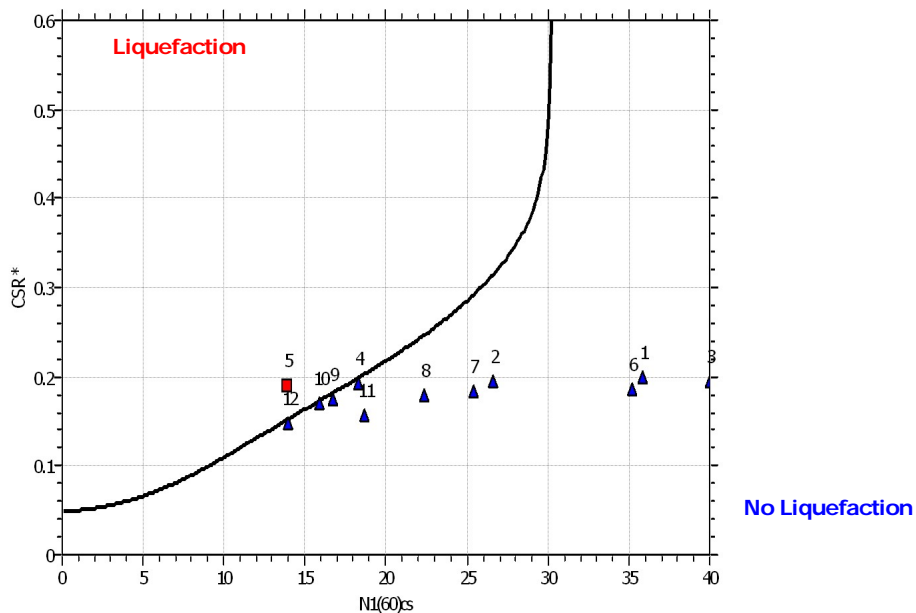
Factor of safety



Settlements (cm)



$M_w=7^{1/2}$, $\sigma'_v=1$ atm base curve



:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (m)	Sigma (kPa)	u (kPa)	Sigma' (kPa)	r _d	CSR	MSF	CSR _{eq,M=7.5}	K _{sigma}	CSR*
1	1.60	30.40	15.70	14.70	0.99	0.31	1.85	0.17	1.00	0.17
2	3.20	60.80	31.39	29.41	0.98	0.30	1.85	0.16	1.00	0.16
3	4.50	85.50	44.15	41.35	0.97	0.30	1.85	0.16	1.00	0.16
4	6.00	114.00	58.86	55.14	0.95	0.29	1.85	0.16	1.00	0.16
5	7.50	142.50	73.58	68.92	0.94	0.29	1.85	0.16	1.00	0.16
6	9.00	171.00	88.29	82.71	0.93	0.29	1.85	0.16	1.00	0.16
7	10.50	199.50	103.00	96.50	0.89	0.28	1.85	0.15	0.98	0.15
8	12.00	228.00	117.72	110.28	0.85	0.26	1.85	0.14	0.95	0.15
9	13.50	256.50	132.44	124.06	0.81	0.25	1.85	0.14	0.93	0.15
10	15.00	285.00	147.15	137.85	0.77	0.24	1.85	0.13	0.92	0.14
11	18.00	342.00	176.58	165.42	0.69	0.21	1.85	0.12	0.89	0.13
12	20.00	380.00	196.20	183.80	0.64	0.20	1.85	0.11	0.87	0.12

Depth : Depth from free surface, at which SPT was performed (m)
 Sigma : Total overburden pressure at test point, during earthquake (kPa)
 u : Water pressure at test point, during earthquake (kPa)
 Sigma' : Effective overburden pressure, during earthquake (kPa)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 CSR_{eq,M=7.5} : CSR adjusted for M= 7.5
 K_{sigma} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation CRR_{7.5} ::

Point ID	Field SPT	C _n	C _e	C _b	C _r	C _s	N ₁₍₆₀₎	DeltaN	N _{1(60)cs}	CRR _{7.5}
1	21.00	1.70	0.90	1.00	0.80	1.00	25.70	10.14	35.84	2.00
2	16.00	1.47	0.90	1.00	0.85	1.00	18.03	8.61	26.64	0.32
3	26.00	1.31	0.90	1.00	0.95	1.00	29.18	10.84	40.02	2.00
4	11.00	1.18	0.90	1.00	0.95	1.00	11.10	7.22	18.32	0.20
5	15.00	1.08	0.90	1.00	0.95	1.00	13.86	0.04	13.90	0.15
6	39.00	1.00	0.90	1.00	1.00	1.00	35.21	0.00	35.21	2.00
7	30.00	0.94	0.90	1.00	1.00	1.00	25.38	0.00	25.38	0.29
8	28.00	0.89	0.90	1.00	1.00	1.00	22.37	0.00	22.37	0.25
9	22.00	0.84	0.90	1.00	1.00	1.00	16.69	0.00	16.69	0.18
10	22.00	0.80	0.90	1.00	1.00	1.00	15.93	0.00	15.93	0.17
11	28.00	0.74	0.90	1.00	1.00	1.00	18.67	0.00	18.67	0.20
12	22.00	0.71	0.90	1.00	1.00	1.00	13.98	0.00	13.98	0.15

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Liner correction factor
 N₁₍₆₀₎ : Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 N_{1(60)cs} : Corrected N₁₍₆₀₎ value for fines
 CRR_{7.5} : Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	N ₁₍₆₀₎	N ₁	FS _L	e _v (%)	Settle. (cm)
1	35.84	29.87	5.00	0.00	0.00
2	26.64	22.20	1.61	0.04	0.00
3	40.02	33.35	5.00	0.00	0.00
4	18.32	15.26	1.04	1.02	0.00
5	13.90	11.58	0.80	3.20	0.00
6	35.21	29.34	5.00	0.00	0.00
7	25.38	21.15	1.58	0.05	0.00
8	22.37	18.64	1.37	0.13	0.00

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (cm)
9	16.69	13.91	1.04	1.11	0.00
10	15.93	13.27	1.02	1.36	0.00
11	18.67	15.56	1.29	0.21	0.00
12	13.98	11.65	1.03	1.33	0.00

Total settlement : 0.00

$N_{1(60)}$: Stress normalized and corrected SPT blow count
 N_1 : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle.: Calculated settlement (cm)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w_z	I_L
1	0.00	9.20	0.00
2	0.00	8.40	0.00
3	0.00	7.75	0.00
4	0.00	7.00	0.00
5	0.20	6.25	1.86
6	0.00	5.50	0.00
7	0.00	4.75	0.00
8	0.00	4.00	0.00
9	0.00	3.25	0.00
10	0.00	2.50	0.00
11	0.00	1.00	0.00
12	0.00	0.00	0.00

Overall potential I_L : 1.86

$I_L = 0.00$ - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 $I_L > 15$ - Liquefaction certain

LIQUEFACTION ANALYSIS REPORT

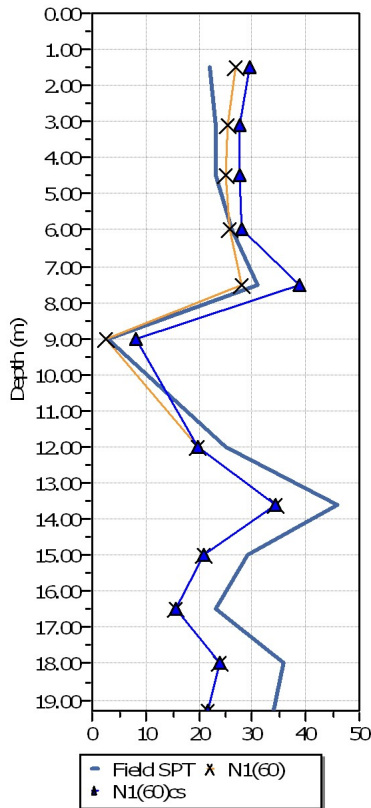
Project title : Verifiche liquefazione - Regione Veneto

Project subtitle : VR-SC39

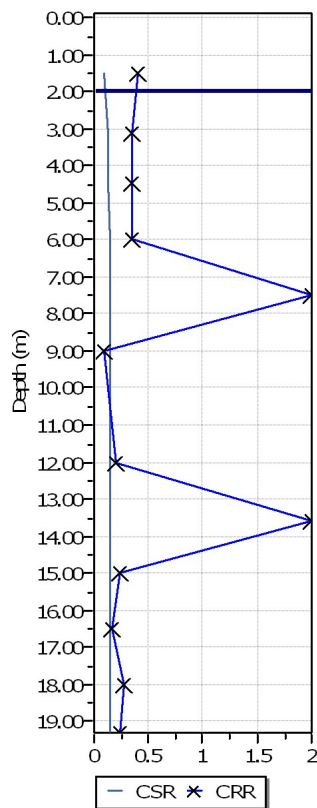
Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	2.00 m
Analysis type:	Deterministic	Earthquake magnitude M_w :	5.90
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.20

SPT data graph



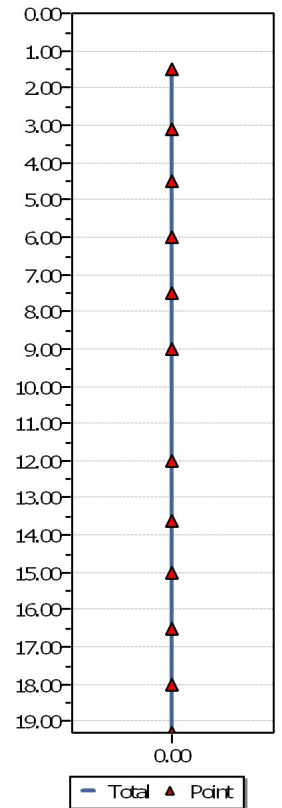
Shear stress ratio



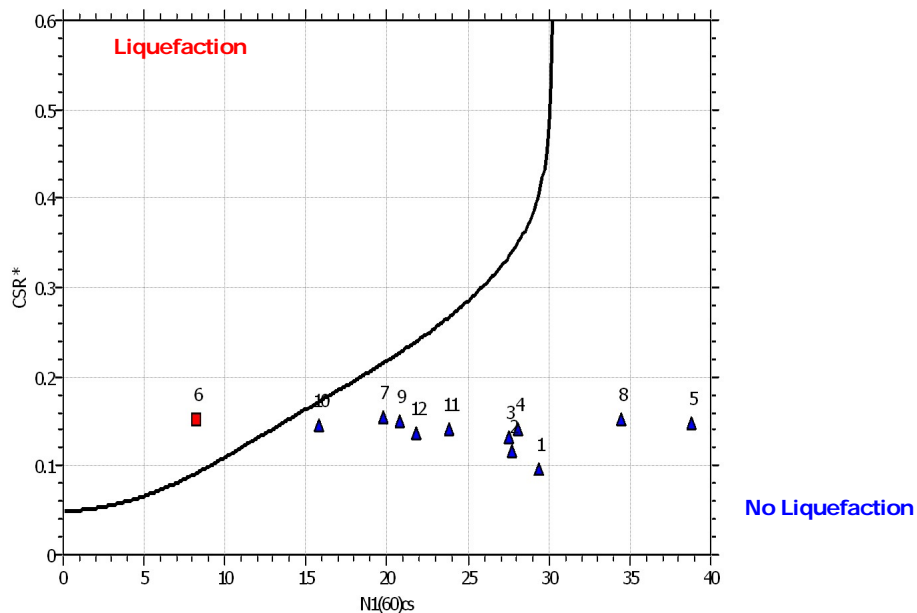
Factor of safety



Settlements (cm)



$M_w=7^{1/2}$, $\sigma'_v=1$ atm base curve



:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (m)	Sigma (kPa)	u (kPa)	Sigma' (kPa)	r _d	CSR	MSF	CSR _{eq,M=7.5}	K _{sigma}	CSR*
1	1.50	28.50	0.00	28.50	0.99	0.15	1.85	0.08	1.00	0.08
2	3.10	58.90	10.79	48.11	0.98	0.18	1.85	0.10	1.00	0.10
3	4.50	85.50	24.52	60.98	0.97	0.20	1.85	0.11	1.00	0.11
4	6.00	114.00	39.24	74.76	0.95	0.22	1.85	0.12	1.00	0.12
5	7.50	142.50	53.95	88.55	0.94	0.23	1.85	0.12	1.00	0.12
6	9.00	171.00	68.67	102.33	0.93	0.23	1.85	0.13	1.00	0.13
7	12.00	228.00	98.10	129.90	0.85	0.22	1.85	0.12	0.95	0.13
8	13.60	258.40	113.80	144.60	0.81	0.22	1.85	0.12	0.93	0.13
9	15.00	285.00	127.53	157.47	0.77	0.21	1.85	0.11	0.91	0.12
10	16.50	313.50	142.25	171.25	0.73	0.20	1.85	0.11	0.90	0.12
11	18.00	342.00	156.96	185.04	0.69	0.19	1.85	0.10	0.88	0.12
12	19.30	366.70	169.71	196.99	0.66	0.18	1.85	0.10	0.87	0.11

Depth : Depth from free surface, at which SPT was performed (m)
 Sigma : Total overburden pressure at test point, during earthquake (kPa)
 u : Water pressure at test point, during earthquake (kPa)
 Sigma' : Effective overburden pressure, during earthquake (kPa)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 CSR_{eq,M=7.5} : CSR adjusted for M= 7.5
 K_{sigma} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation CRR_{7.5} ::

Point ID	Field SPT	C _n	C _e	C _b	C _r	C _s	N ₁₍₆₀₎	DeltaN	N _{1(60)cs}	CRR _{7.5}
1	22.00	1.70	0.90	1.00	0.80	1.00	26.93	2.40	29.33	0.40
2	23.00	1.44	0.90	1.00	0.85	1.00	25.37	2.35	27.72	0.34
3	23.00	1.28	0.90	1.00	0.95	1.00	25.18	2.35	27.53	0.34
4	26.00	1.16	0.90	1.00	0.95	1.00	25.71	2.37	28.08	0.35
5	31.00	1.06	0.90	1.00	0.95	1.00	28.17	10.63	38.80	2.00
6	3.00	0.99	0.90	1.00	1.00	1.00	2.67	5.53	8.20	0.09
7	25.00	0.88	0.90	1.00	1.00	1.00	19.74	0.00	19.74	0.21
8	46.00	0.83	0.90	1.00	1.00	1.00	34.43	0.00	34.43	2.00
9	29.00	0.80	0.90	1.00	1.00	1.00	20.80	0.00	20.80	0.23
10	23.00	0.76	0.90	1.00	1.00	1.00	15.82	0.00	15.82	0.17
11	36.00	0.74	0.90	1.00	1.00	1.00	23.82	0.00	23.82	0.27
12	34.00	0.71	0.90	1.00	1.00	1.00	21.80	0.00	21.80	0.24

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Liner correction factor
 N₁₍₆₀₎ : Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 N_{1(60)cs} : Corrected N₁₍₆₀₎ value for fines
 CRR_{7.5} : Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	N ₁₍₆₀₎	N ₁	FS _L	e _v (%)	Settle. (cm)
1	29.33	24.44	4.18	0.00	0.00
2	27.72	23.10	2.93	0.00	0.00
3	27.53	22.94	2.55	0.00	0.00
4	28.08	23.40	2.48	0.00	0.00
5	38.80	32.33	5.00	0.00	0.00
6	8.20	6.84	0.60	4.21	0.00
7	19.74	16.45	1.40	0.13	0.00
8	34.43	28.69	5.00	0.00	0.00

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (cm)
9	20.80	17.33	1.52	0.08	0.00
10	15.82	13.18	1.18	0.41	0.00
11	23.82	19.85	1.89	0.01	0.00
12	21.80	18.17	1.75	0.03	0.00

Total settlement : 0.00

$N_{1(60)}$: Stress normalized and corrected SPT blow count
 N_1 : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle.: Calculated settlement (cm)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w_z	I_L
1	0.00	9.25	0.00
2	0.00	8.45	0.00
3	0.00	7.75	0.00
4	0.00	7.00	0.00
5	0.00	6.25	0.00
6	0.40	5.50	3.27
7	0.00	4.00	0.00
8	0.00	3.20	0.00
9	0.00	2.50	0.00
10	0.00	1.75	0.00
11	0.00	1.00	0.00
12	0.00	0.35	0.00

Overall potential I_L : 3.27

$I_L = 0.00$ - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 $I_L > 15$ - Liquefaction certain

LIQUEFACTION ANALYSIS REPORT

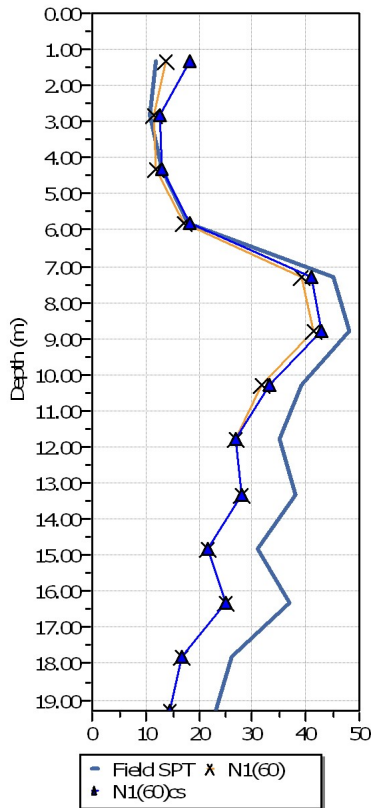
Project title : Verifiche liquefazione - Regione Veneto

Project subtitle : VR-SC46

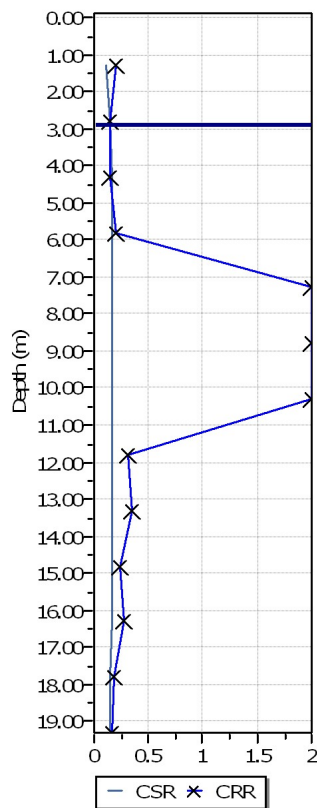
Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	2.90 m
Analysis type:	Deterministic	Earthquake magnitude M_w :	5.90
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.20

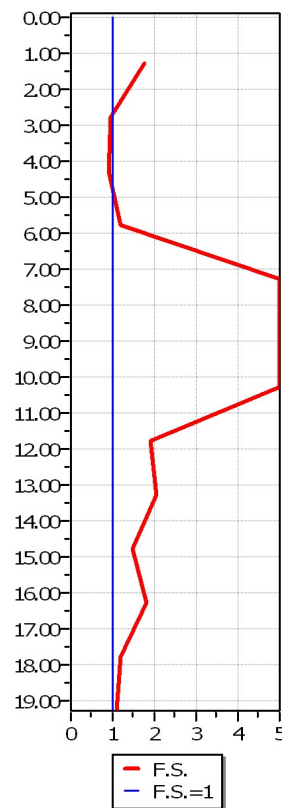
SPT data graph



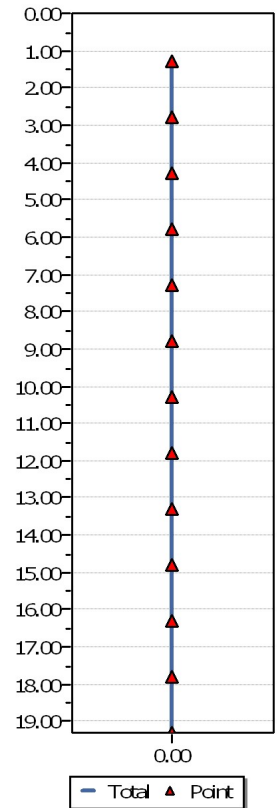
Shear stress ratio



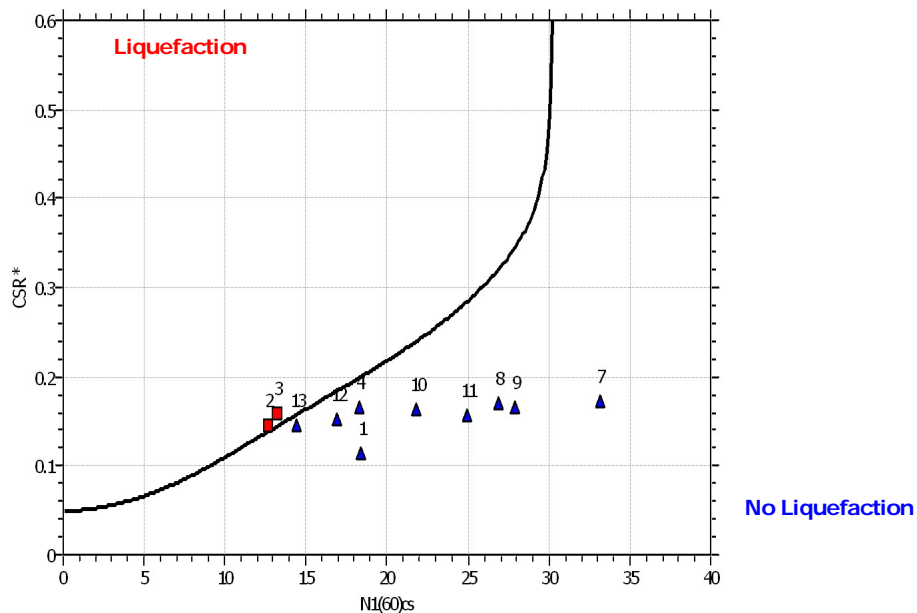
Factor of safety



Settlements (cm)



$M_w=7^{1/2}$, $\sigma'_v=1$ atm base curve



:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (m)	Sigma (kPa)	u (kPa)	Sigma' (kPa)	r _d	CSR	MSF	CSR _{eq,M=7.5}	K _{sigma}	CSR*
1	1.30	24.70	3.92	20.78	0.99	0.18	1.85	0.10	1.00	0.10
2	2.80	53.20	18.64	34.56	0.98	0.23	1.85	0.12	1.00	0.12
3	4.30	81.70	33.35	48.35	0.97	0.24	1.85	0.13	1.00	0.13
4	5.80	110.20	48.07	62.13	0.96	0.25	1.85	0.14	1.00	0.14
5	7.30	138.70	62.78	75.92	0.94	0.26	1.85	0.14	1.00	0.14
6	8.80	167.20	77.50	89.70	0.93	0.26	1.85	0.14	0.98	0.14
7	10.30	195.70	92.21	103.49	0.90	0.25	1.85	0.14	0.96	0.14
8	11.80	224.20	106.93	117.27	0.86	0.25	1.85	0.13	0.94	0.14
9	13.30	252.70	121.64	131.06	0.82	0.24	1.85	0.13	0.92	0.14
10	14.80	281.20	136.36	144.84	0.78	0.23	1.85	0.12	0.91	0.14
11	16.30	309.70	151.07	158.63	0.74	0.22	1.85	0.12	0.89	0.13
12	17.80	338.20	165.79	172.41	0.70	0.21	1.85	0.11	0.88	0.13
13	19.30	366.70	180.50	186.20	0.66	0.19	1.85	0.11	0.87	0.12

Depth : Depth from free surface, at which SPT was performed (m)
 Sigma : Total overburden pressure at test point, during earthquake (kPa)
 u : Water pressure at test point, during earthquake (kPa)
 Sigma' : Effective overburden pressure, during earthquake (kPa)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 CSR_{eq,M=7.5} : CSR adjusted for M= 7.5
 K_{sigma} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation CRR_{7.5} ::

Point ID	Field SPT	C _n	C _e	C _b	C _r	C _s	N ₁₍₆₀₎	DeltaN	N _{1(60)cs}	CRR _{7.5}
1	12.00	1.70	0.90	1.00	0.75	1.00	13.77	4.57	18.34	0.20
2	11.00	1.37	0.90	1.00	0.85	1.00	11.54	1.12	12.66	0.14
3	13.00	1.21	0.90	1.00	0.85	1.00	12.06	1.13	13.19	0.14
4	18.00	1.11	0.90	1.00	0.95	1.00	17.02	1.24	18.26	0.20
5	45.00	1.02	0.90	1.00	0.95	1.00	39.36	1.72	41.08	2.00
6	48.00	0.96	0.90	1.00	1.00	1.00	41.32	1.76	43.08	2.00
7	39.00	0.90	0.90	1.00	1.00	1.00	31.63	1.55	33.19	2.00
8	35.00	0.85	0.90	1.00	1.00	1.00	26.92	0.00	26.92	0.32
9	38.00	0.81	0.90	1.00	1.00	1.00	27.86	0.00	27.86	0.34
10	31.00	0.78	0.90	1.00	1.00	1.00	21.76	0.00	21.76	0.24
11	37.00	0.75	0.90	1.00	1.00	1.00	24.94	0.00	24.94	0.28
12	26.00	0.72	0.90	1.00	1.00	1.00	16.89	0.00	16.89	0.18
13	23.00	0.70	0.90	1.00	1.00	1.00	14.43	0.00	14.43	0.16

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Liner correction factor
 N₁₍₆₀₎ : Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 N_{1(60)cs} : Corrected N₁₍₆₀₎ value for fines
 CRR_{7.5} : Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	N ₁₍₆₀₎	N ₁	FS _L	e _v (%)	Settle. (cm)
1	18.34	15.29	1.74	0.03	0.00
2	12.66	10.55	0.94	3.18	0.00
3	13.19	10.99	0.91	3.22	0.00
4	18.26	15.22	1.20	0.33	0.00
5	41.08	34.24	5.00	0.00	0.00
6	43.08	35.90	5.00	0.00	0.00

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (cm)
7	33.19	27.66	5.00	0.00	0.00
8	26.92	22.44	1.89	0.01	0.00
9	27.86	23.22	2.07	0.00	0.00
10	21.76	18.13	1.47	0.09	0.00
11	24.94	20.79	1.80	0.02	0.00
12	16.89	14.07	1.21	0.34	0.00
13	14.43	12.02	1.08	0.84	0.00

Total settlement : 0.00

$N_{1(60)}$: Stress normalized and corrected SPT blow count
 N_1 : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle.: Calculated settlement (cm)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w_z	I_L
1	0.00	9.35	0.00
2	0.06	8.60	0.71
3	0.09	7.85	1.09
4	0.00	7.10	0.00
5	0.00	6.35	0.00
6	0.00	5.60	0.00
7	0.00	4.85	0.00
8	0.00	4.10	0.00
9	0.00	3.35	0.00
10	0.00	2.60	0.00
11	0.00	1.85	0.00
12	0.00	1.10	0.00
13	0.00	0.35	0.00

Overall potential I_L : 1.81

$I_L = 0.00$ - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 $I_L > 15$ - Liquefaction certain

LIQUEFACTION ANALYSIS REPORT

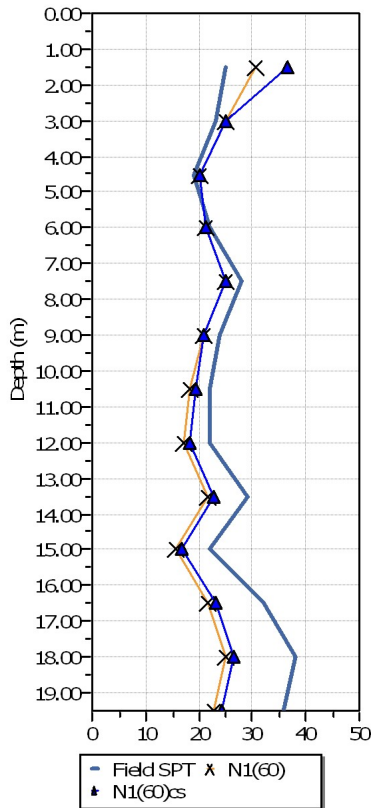
Project title : Verifiche liquefazione - Regione Veneto

Project subtitle : VR-SC48

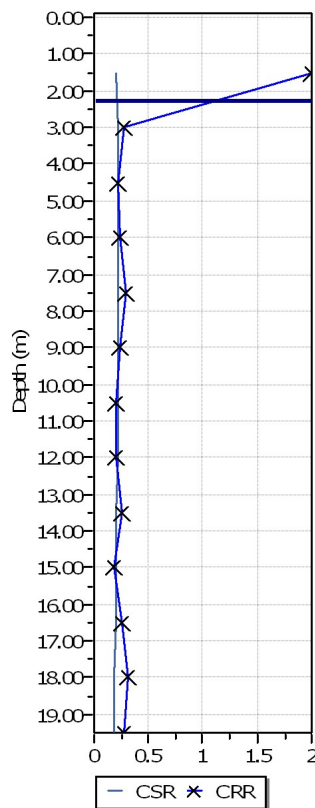
Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	2.30 m
Analysis type:	Deterministic	Earthquake magnitude M_w :	6.00
Analysis method:	NCEER 1998	Peak ground acceleration:	0.27 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.20

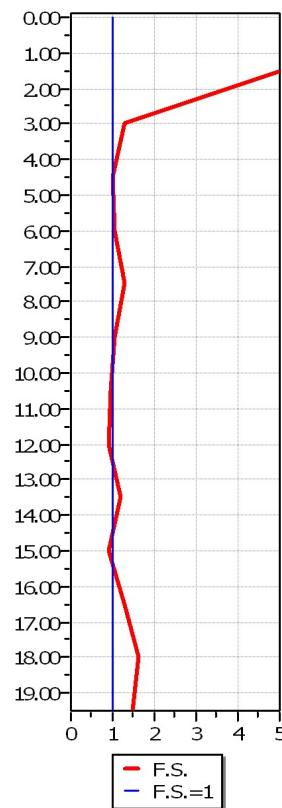
SPT data graph



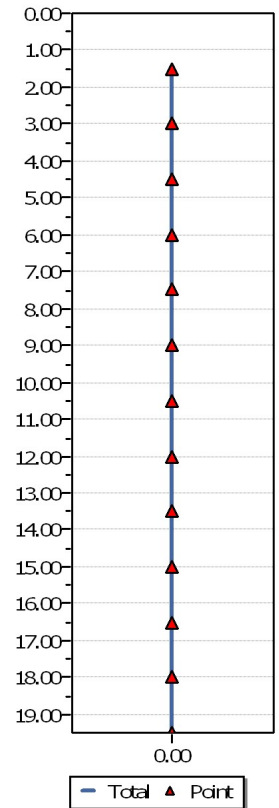
Shear stress ratio



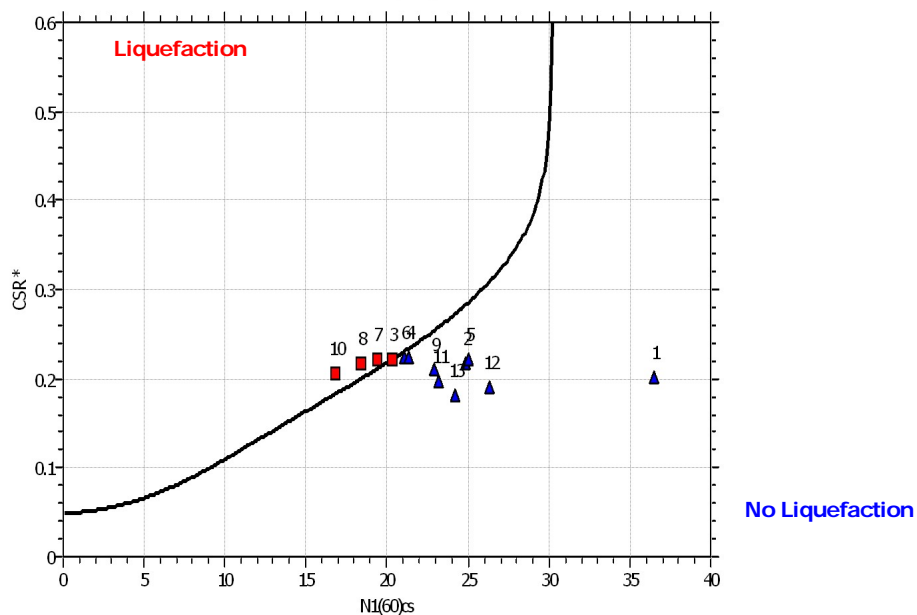
Factor of safety



Settlements (cm)



$M_w=7^{1/2}$, $\sigma'_v=1$ atm base curve



:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (m)	Sigma (kPa)	u (kPa)	Sigma' (kPa)	r _d	CSR	MSF	CSR _{eq,M=7.5}	K _{sigma}	CSR*
1	1.50	28.50	11.77	16.73	0.99	0.30	1.77	0.17	1.00	0.17
2	3.00	57.00	26.49	30.51	0.98	0.32	1.77	0.18	1.00	0.18
3	4.50	85.50	41.20	44.30	0.97	0.33	1.77	0.18	1.00	0.18
4	6.00	114.00	55.92	58.08	0.95	0.33	1.77	0.19	1.00	0.19
5	7.50	142.50	70.63	71.87	0.94	0.33	1.77	0.19	1.00	0.19
6	9.00	171.00	85.35	85.65	0.93	0.33	1.77	0.18	0.99	0.19
7	10.50	199.50	100.06	99.44	0.89	0.32	1.77	0.18	0.97	0.18
8	12.00	228.00	114.78	113.22	0.85	0.30	1.77	0.17	0.94	0.18
9	13.50	256.50	129.49	127.01	0.81	0.29	1.77	0.16	0.93	0.18
10	15.00	285.00	144.21	140.79	0.77	0.28	1.77	0.16	0.91	0.17
11	16.50	313.50	158.92	154.58	0.73	0.26	1.77	0.15	0.89	0.17
12	18.00	342.00	173.64	168.36	0.69	0.25	1.77	0.14	0.88	0.16
13	19.50	370.50	188.35	182.15	0.65	0.23	1.77	0.13	0.87	0.15

Depth : Depth from free surface, at which SPT was performed (m)
 Sigma : Total overburden pressure at test point, during earthquake (kPa)
 u : Water pressure at test point, during earthquake (kPa)
 Sigma' : Effective overburden pressure, during earthquake (kPa)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 CSR_{eq,M=7.5} : CSR adjusted for M= 7.5
 K_{sigma} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation CRR_{7.5} ::

Point ID	Field SPT	C _n	C _e	C _b	C _r	C _s	N ₁₍₆₀₎	DeltaN	N _{1(60)cs}	CRR _{7.5}
1	25.00	1.70	0.90	1.00	0.80	1.00	30.60	5.86	36.46	2.00
2	23.00	1.41	0.90	1.00	0.85	1.00	24.85	0.00	24.85	0.28
3	19.00	1.25	0.90	1.00	0.95	1.00	20.32	0.00	20.32	0.22
4	22.00	1.13	0.90	1.00	0.95	1.00	21.34	0.00	21.34	0.23
5	28.00	1.05	0.90	1.00	0.95	1.00	25.03	0.00	25.03	0.29
6	24.00	0.97	0.90	1.00	1.00	1.00	21.05	0.00	21.05	0.23
7	22.00	0.92	0.90	1.00	1.00	1.00	18.15	1.26	19.41	0.21
8	22.00	0.87	0.90	1.00	1.00	1.00	17.18	1.24	18.42	0.20
9	29.00	0.83	0.90	1.00	1.00	1.00	21.55	1.34	22.89	0.25
10	22.00	0.79	0.90	1.00	1.00	1.00	15.63	1.21	16.84	0.18
11	32.00	0.76	0.90	1.00	1.00	1.00	21.82	1.34	23.16	0.26
12	38.00	0.73	0.90	1.00	1.00	1.00	24.94	1.41	26.35	0.31
13	36.00	0.70	0.90	1.00	1.00	1.00	22.81	1.36	24.17	0.27

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Liner correction factor
 N₁₍₆₀₎ : Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 N_{1(60)cs} : Corrected N₁₍₆₀₎ value for fines
 CRR_{7.5} : Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	N ₁₍₆₀₎	N ₁	FS _L	e _v (%)	Settle. (cm)
1	36.46	30.38	5.00	0.00	0.00
2	24.85	20.71	1.30	0.16	0.00
3	20.32	16.93	1.00	1.58	0.00
4	21.34	17.78	1.05	0.84	0.00
5	25.03	20.86	1.28	0.17	0.00
6	21.05	17.54	1.03	1.03	0.00

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (cm)
7	19.41	16.17	0.95	2.35	0.00
8	18.42	15.35	0.92	2.54	0.00
9	22.89	19.07	1.20	0.29	0.00
10	16.84	14.03	0.89	2.73	0.00
11	23.16	19.30	1.30	0.17	0.00
12	26.35	21.96	1.63	0.04	0.00
13	24.17	20.14	1.49	0.07	0.00

Total settlement : 0.00

$N_{1(60)}$: Stress normalized and corrected SPT blow count
 N_1 : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle.: Calculated settlement (cm)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w_z	I_L
1	0.00	9.25	0.00
2	0.00	8.50	0.00
3	0.00	7.75	0.02
4	0.00	7.00	0.00
5	0.00	6.25	0.00
6	0.00	5.50	0.00
7	0.05	4.75	0.33
8	0.08	4.00	0.46
9	0.00	3.25	0.00
10	0.11	2.50	0.40
11	0.00	1.75	0.00
12	0.00	1.00	0.00
13	0.00	0.25	0.00

Overall potential I_L : 1.21

$I_L = 0.00$ - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 $I_L > 15$ - Liquefaction certain

LIQUEFACTION ANALYSIS REPORT

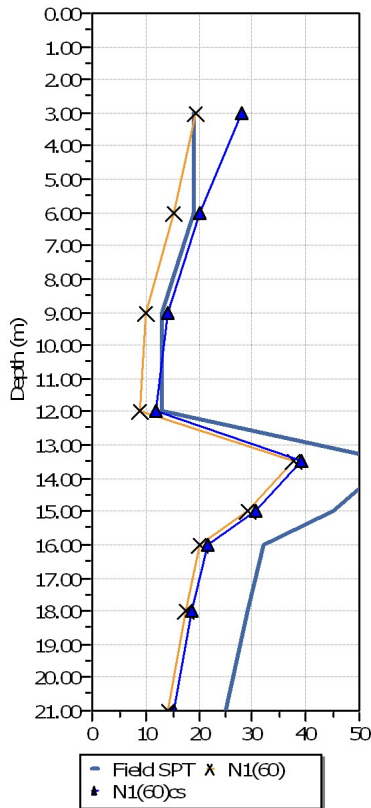
Project title : Verifiche liquefazione - Regione Veneto

Project subtitle : VR-SC53

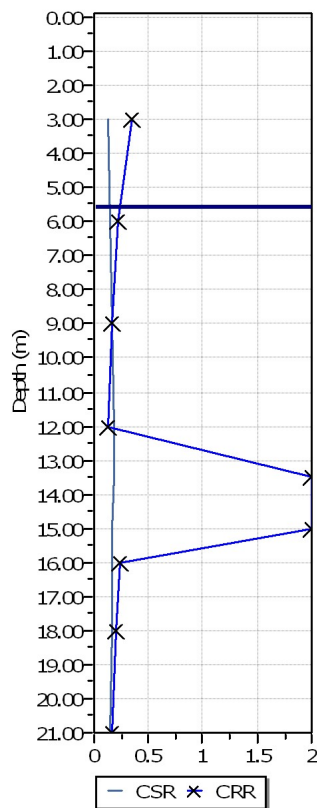
Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	5.60 m
Analysis type:	Deterministic	Earthquake magnitude M_w :	6.00
Analysis method:	NCEER 1998	Peak ground acceleration:	0.27 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.20

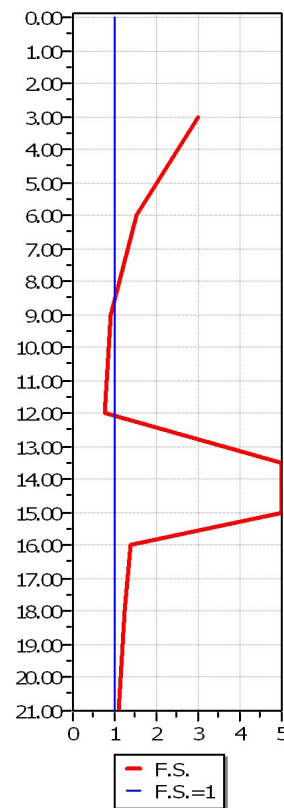
SPT data graph



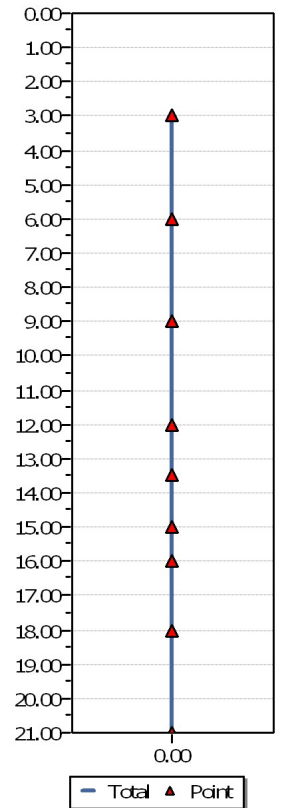
Shear stress ratio



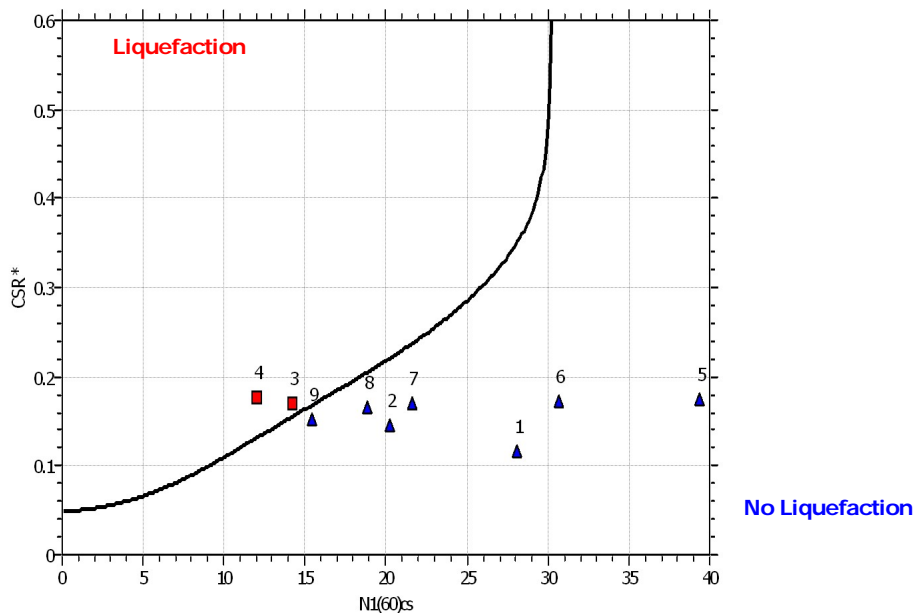
Factor of safety



Settlements (cm)



$M_w=7^{1/2}$, $\sigma'_v=1$ atm base curve



:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (m)	Sigma (kPa)	u (kPa)	Sigma' (kPa)	r _d	CSR	MSF	CSR _{eq,M=7.5}	K _{sigma}	CSR*
1	3.00	57.00	0.00	57.00	0.98	0.17	1.77	0.10	1.00	0.10
2	6.00	114.00	23.54	90.46	0.95	0.21	1.77	0.12	0.98	0.12
3	9.00	171.00	52.97	118.03	0.93	0.24	1.77	0.13	0.94	0.14
4	12.00	228.00	82.40	145.60	0.85	0.23	1.77	0.13	0.90	0.15
5	13.50	256.50	97.12	159.38	0.81	0.23	1.77	0.13	0.89	0.15
6	15.00	285.00	111.83	173.17	0.77	0.22	1.77	0.13	0.88	0.14
7	16.00	304.00	121.64	182.36	0.75	0.22	1.77	0.12	0.87	0.14
8	18.00	342.00	141.26	200.74	0.69	0.21	1.77	0.12	0.85	0.14
9	21.00	399.00	170.69	228.31	0.61	0.19	1.77	0.11	0.83	0.13

Depth : Depth from free surface, at which SPT was performed (m)
 Sigma : Total overburden pressure at test point, during earthquake (kPa)
 u : Water pressure at test point, during earthquake (kPa)
 Sigma' : Effective overburden pressure, during earthquake (kPa)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 CSR_{eq,M=7.5} : CSR adjusted for M= 7.5
 K_{sigma} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation CRR_{7.5} ::

Point ID	Field SPT	C _n	C _e	C _b	C _r	C _s	N ₁₍₆₀₎	DeltaN	N _{1(60)cs}	CRR _{7.5}
1	19.00	1.32	0.90	1.00	0.85	1.00	19.25	8.85	28.10	0.35
2	19.00	0.95	0.90	1.00	0.95	1.00	15.48	4.71	20.19	0.22
3	13.00	0.85	0.90	1.00	1.00	1.00	9.97	4.29	14.26	0.16
4	13.00	0.78	0.90	1.00	1.00	1.00	9.10	2.94	12.04	0.13
5	56.00	0.75	0.90	1.00	1.00	1.00	37.67	1.68	39.35	2.00
6	45.00	0.72	0.90	1.00	1.00	1.00	29.17	1.50	30.67	2.00
7	32.00	0.70	0.90	1.00	1.00	1.00	20.26	1.31	21.57	0.24
8	29.00	0.67	0.90	1.00	1.00	1.00	17.58	1.25	18.83	0.20
9	25.00	0.64	0.90	1.00	1.00	1.00	14.29	1.18	15.47	0.17

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Liner correction factor
 N₁₍₆₀₎ : Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 N_{1(60)cs} : Corrected N₁₍₆₀₎ value for fines
 CRR_{7.5} : Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	N ₁₍₆₀₎	N ₁	FS _L	e _v (%)	Settle. (cm)
1	28.10	23.42	3.02	0.00	0.00
2	20.19	16.82	1.51	0.08	0.00
3	14.26	11.88	0.91	3.07	0.00
4	12.04	10.03	0.75	3.49	0.00
5	39.35	32.80	5.00	0.00	0.00
6	30.67	25.56	5.00	0.00	0.00
7	21.57	17.98	1.38	0.13	0.00
8	18.83	15.69	1.24	0.27	0.00
9	15.47	12.89	1.10	0.69	0.00

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (cm)
----------	-------------	-------	--------	--------------	-----------------

Total settlement : 0.00

$N_{1(60)}$: Stress normalized and corrected SPT blow count
 N_1 : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle.: Calculated settlement (cm)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w_z	I_L
1	0.00	8.50	0.00
2	0.00	7.00	0.00
3	0.09	5.50	1.51
4	0.25	4.00	3.04
5	0.00	3.25	0.00
6	0.00	2.50	0.00
7	0.00	2.00	0.00
8	0.00	1.00	0.00

Overall potential I_L : 4.55

$I_L = 0.00$ - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 $I_L > 15$ - Liquefaction certain